COMBAT AIR FORCES CAMPAIGN LEVEL MODERNIZATION PLANNING:

A STUDY IN GROUP DECISION MAKING

THESIS

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AFIT/GCA/ENV/03-10

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Ian L. Walker

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Abstract

Modernization is a critical component of the current transformation effort within the Department of Defense (DoD). Effective and efficient modernization planning will provide for the improved allocation of limited funding. The Air Force currently conducts capabilities based modernization planning to identify shortfalls. Air Combat Command (ACC) utilizes multi-objective decision analysis (MODA) techniques to support the modernization planning process (MPP). A MODA model has been created to identify and quantify capability shortfalls across a diverse range of mission areas. Groups of subject matter experts are utilized to provide model inputs improving the usefulness and credibility of the model.

The intent of this research effort is to document the ACC modernization model and provide insight into their use of groups. A methodology is created to identify appropriate group decision making techniques for use in MODA. The resulting taxonomy table is then used to analyze the group decision process used for the ACC model. The documentation of the model provides a reference of MODA use in modernization planning. The methodology created will provide a reference for the use of group decision making techniques in MODA. The identification of areas where group decision making techniques can be applied to the ACC model provides insight capable of strengthening the model and its output. This will provide improved quantitative information to modernization decision makers.

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I. Introduction

Overview

The issue of modernization is of critical importance to the United States Air Force. The Air Force defines modernization as "planned increases in technical sophistication of forces, units, weapon systems, and equipment" (AFPD 90-11, 2000:11). The aging of legacy weapons systems and the high demands placed on the force due to the war on terrorism accentuate the Air Force's need to continue improving its capabilities. Increases in technology are essential in ensuring the Air Force can continue to dominate as the global leader in aerospace power.

Modernization of the Air Force is one critical part of the Department of Defense (DoD) effort to transform the military forces of the United States. "In Air Force parlance, transformation means a fundamental change that yields "order-of-magnitude" leaps in power rather than incremental gains" (Dudney, 2002). Transformation is by no means a new concept, but has become critical due to the changing threat environment and the aging of military equipment.

The transformation goal of the Air Force is to be a "capabilities-focused expeditionary air and space force" (Himes, 2002). In order to meet this goal, the research, development, and procurement of weapon systems is a focus of Air Force transformation efforts (Dudney, 2002). Transformation is accomplished in part through

modernization to improve capabilities. This will allow the Air Force to maintain the advantage over all current and future enemies.

The task of modernizing the Air Force is formidable due to the size of the force, the high level of technology involved, and the complexity of the operating environment. The Modernization Planning Process (MPP) requires participation at all levels within the Air Force. The MPP is based primarily on the Air Force Strategic Plan (AFSP) and incorporates inputs from the actual war fighters through a requirements generation process. The output of the MPP is of critical importance to the decision making process faced by Air Force leaders.

“Modernization plans identify current and future capabilities, deficiencies in those capabilities, and recommended solutions to noted shortfalls” (AFPD 90-11, 2000:3). Air Force leadership uses the outputs of modernization planning to assist them in the difficult task of resource allocation. The limited funding available for modernization increases the importance of producing sound modernization plans. An overview of the relationship between the MPP and AFSP is provided in Figure 1.

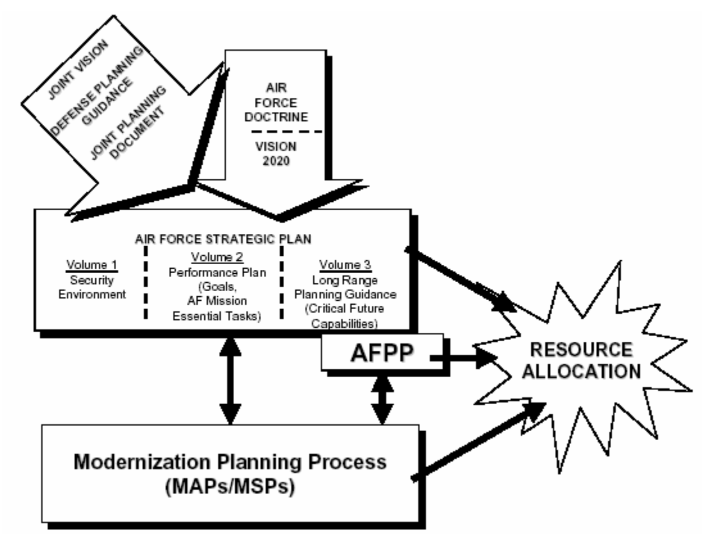

Figure 1. AFSP and the MPP (AFI 10-601, 1999)

Air Combat Command (ACC), the largest of the Air Force major commands (MAJCOMs), bears the responsibility of modernization planning for the Combat Air Forces (CAF). The CAF includes ACC, U.S. Air Forces in Europe (USAFE), Pacific Air Forces (PACAF), Air National Guard (ANG), and the Air Force Reserve Command (AFRC) (Titus, 2002b). ACC bears this responsibility based on the efficiencies of centralized modernization planning. This setup ensures that duplication or diversification of modernization efforts is not encountered between commands.

The goal of modernization planning at the MAJCOM level is the creation of Mission Area Plans (MAPs) for specific mission areas over a 25-year time frame (AFPD 90-11, 2000). Modernization planning is accomplished at ACC using both qualitative and quantitative methods. The planning is complex and is heavily reliant on subject matter experts (SME). In order to improve the ACC MPP, a quantitative decision analysis tool has been created.

A multi-objective decision analysis (MODA) methodology is the basis for the Combat Air Forces Planning and Programming Analytical Tool (CAFPPAT). MODA, in different forms, is widely used in the commercial and public sectors for analysis over a wide variety of decision making scenarios. MODA is a way to add structure, objectivity, and repeatability to complex decisions (Chambal, 2002). These properties make this methodology appropriate for the task of modernization planning based on the need to optimize the allocation of scarce resources.

The annual modernization budget for ACC exceeds $10 billion. However, approximately eighty percent is fenced for development of new aircraft, leaving significantly less to upgrade current systems and develop new weapons and platforms

(Hickman, 2002b). The relatively small portion of modernization funding left over is primarily used to address the capability improvements deemed necessary for aging legacy systems. There are over 400 programs and solutions that compete for the remaining modernization funding. This makes selecting the solutions which provide the largest increase in capability very important.

The CAFPPAT is an analytical model which produces results that are intended to assist decision makers. The outputs generated by the CAFPPAT are not all inclusive answers for decision makers to rely on in modernization planning. The CAFPPAT is a decision support tool to help leadership make modernization planning decisions (Sullivan, 2002). The results of the CAFPPAT, combined with qualitative analysis, can assist decision makers in increasing the effectiveness of the MPP.

CAFPPAT is a hierarchical value model based on scenarios created from defense guidance and the current capabilities of the CAF. The model is created to address real world, future scenarios where the combined capabilities of the CAF would be utilized. The model separately considers the campaign and system levels which allow the identification of the tasks necessary, at each level, to achieve the desired effects. The model provides a construct over which potential solutions can be judged in regards to the mitigation of capability shortfalls.

The outputs of the CAFPPAT are detailed modernization planning and programming scenarios, baseline platform definition, campaign level capability shortfalls, system level capability shortfalls, and the degree to which modernization solutions mitigate capability shortfalls (Hickman, 2002a). The outputs represent quantitatively based, objective information that can be provided to decision makers.

The construction of this model is accomplished by using the subjective opinion of SME. The CAFPPAT utilizes campaign planners, operators, and various other functional personnel to construct the model. Effective and efficient group decision making is fundamental in building and using this model for modernization planning.

There are numerous methodologies available for use in facilitating a decision from a group of SME. The application of these methodologies is often situation and group specific. Certain methodologies yield better results based on group composition or the personalities involved. The overall goal or focus of the group decision can dictate the use of a certain methodology.

Research Scope

The focus of this research centers on the group decision making process utilized for the campaign level of the CAFPPAT. The structuring and weighting of campaign level tasks will be observed to provide the necessary data for analysis. The campaign level is one component of a large, complex modernization model. The other levels of the model are candidates for future research efforts.

Research Objectives

This research effort consists of three objectives which provide a basis for understanding the CAFPPAT and the role of group decision making in decision analysis. The three objectives are as follows:

1. Analyze, generalize and document the CAFPPAT.
2. Based on literature, develop a comprehensive taxonomy for group decision making.

3. Observe, document, and analyze the group decision making process utilized for the CAFPPAT campaign level and provide insight.

Potential Benefits

The potential benefits of this research are two-fold. The documentation of the CAFPPAT will provide a reference for the Air Force and other DoD organizations. When compared to the group decision making taxonomy, the insight into the CAFPPAT campaign level group decision process will provide a benchmark for others to follow. This will assist other organizations in utilizing groups of SME for their decision analysis tools. This can translate into more robust decisions being made, maximizing the capability obtained with the limited funding available.

Additionally, identification of areas for improvement in the campaign level process will allow ACC to further enhance their decision analysis tool. This improvement can increase the fidelity of information provided to other planners, programmers, and decision makers responsible for modernizing the CAF. A visual summary of these benefits is provided in Figure 2. The waterfall impact of improving the utilization of group expertise can ultimately affect the war fighting ability of the Air Force and DoD.

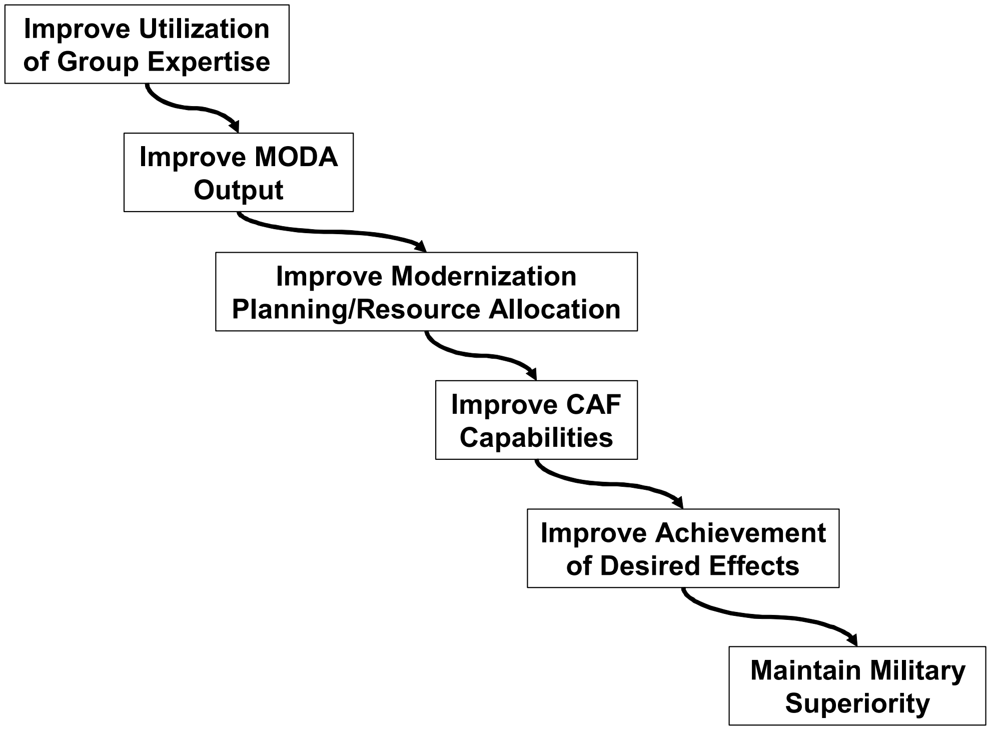

Figure 2. Potential Benefits

Thesis Overview

Chapter II is a literature review which expands on the topic of modernization by providing an overview of the Air Force process. The CAFPPAT is discussed in detail to outline its creation and use for modernization planning within ACC. Finally, a review of group decision making methodologies is presented. This review discusses the origins of the different methodologies and outlines the general process of each. Chapter III provides an in depth review of the methodologies applicable to MODA. This review identifies the advantages, disadvantages, and the appropriate use of the identified methodologies. This review culminates in a methodology table that can be used to identify appropriate methods based on group criteria.

Chapter IV documents an observed campaign level group decision making process. Analysis of this observed process is compared to the methodology table created in Chapter III. This analysis provides insight into the current process utilized by ACC. Chapter V reviews the methodology constructed and its use in decision analysis. Conclusions and recommendations are provided with suggestions for further research regarding this topic.

II. Literature Review

Chapter Overview

This chapter provides an overview of the current Air Force modernization effort and examines a model created by ACC to assist in modernization planning. Group decision making is fundamental to the use of this model and a comprehensive review of applicable methodologies is presented.

Transformation and Modernization

In the last decade, the issue of transformation has grown in importance within the DoD. The end of the cold war and the emergence of smaller, but very capable, threats to national security has dictated a review of how the DoD accomplishes its mission. The result of this assessment is the need for transformation to a force better suited to fight and win against current and future threats.

The Air Force is engaged in transformation efforts by attempting to reshape the force into a “light, lean, and lethal expeditionary force” (Aguilar, 2002). The creation of the Expeditionary Aerospace Force (EAF) is one example of Air Force transformation. The transformation effort is conducted through organizational changes, revised concepts of operations (CONOPS), and advanced technologies (Deptula, 2001). Modernization yields advanced technologies and, as previously defined, is the planned increase of Air Force technical sophistication. This increase in technology is a critical component of the overall transformation effort.

The focus of transformation and modernization is the capabilities that will be required to fight in future conflicts. The goal is to improve the capabilities of the Air

Force to ensure desired effects can be obtained. The two focus areas for modernization and transformation, in regards to war fighting equipment, are maintaining current legacy systems and developing new systems. Capabilities are maintained and increased through sustaining and improving the legacy systems. Increased efficiency and new capabilities are achieved through development of new systems. The other elements of transformation, organizational changes and improved CONOPS, also help to improve capabilities. This relationship is depicted graphically in Figure 3.

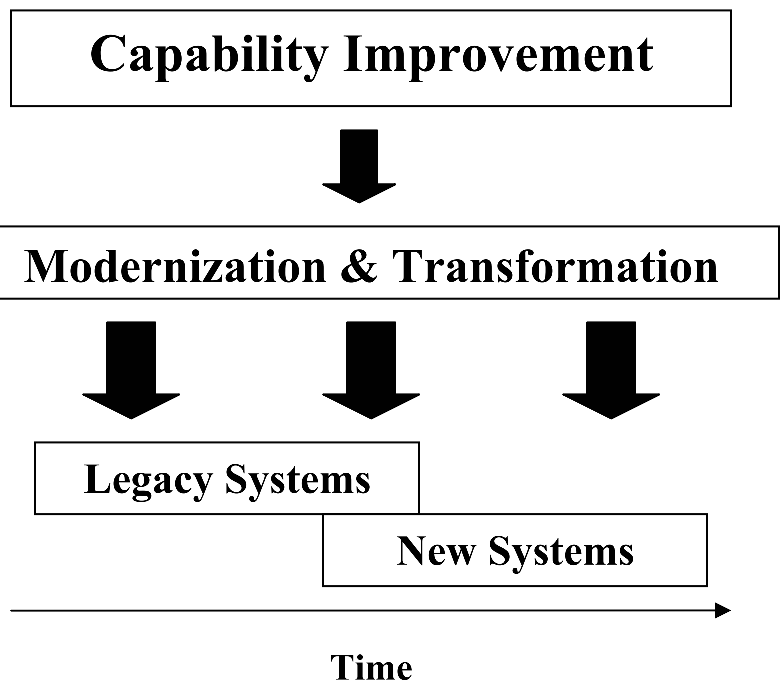

Figure 3. Capability Improvement (Hickman, 2002c)

Air Force modernization is intended to be time phased and balanced in its application. It is time phased in terms of providing the required capability in congruence with the phasing out of legacy systems. It is balanced in regards to investing across all of the Air Force competencies (Air Force Handbook, 2002).

The capabilities required for success in future conflicts are defined in detail in the AFSP, Volume 3. These are defined as critical future capabilities and are addressed through the combination of vision, CONOPS, innovation, and the MPP. This highlights the fact that Air Force planning is driven by the need to obtain these critical future capabilities. This relationship between capabilities and contributing factors is presented in Figure 4.

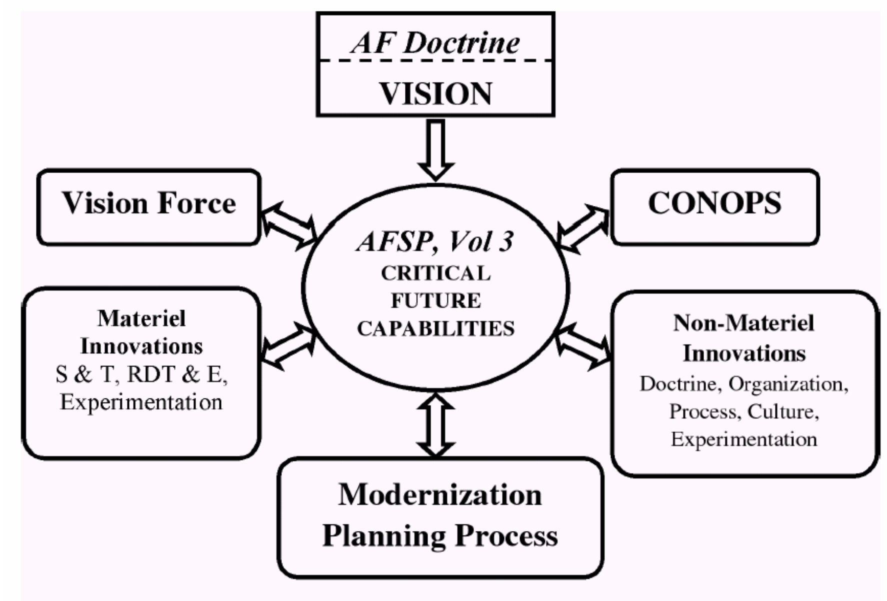

Figure 4. Critical Future Capabilities (AFSP, Vol. 3, 2000)

Modernization planning is a key component of the Planning, Programming, and Budgeting System (PPBS) utilized by the DoD. The goal of the PPBS is "to provide the best mix of forces, equipment, and support attainable within fiscal constraints" (PPBS Primer, 1999:2). The PPBS was created in the 1960s by Secretary of Defense McNamara in an attempt to link the planning and budgeting efforts of the DoD through comprehensive planning.

This dynamic, iterative process has a two-year cycle, but consists of many phases that overlap. Each cycle starts with national defense policy and culminates in a budget submission by the President to Congress (PPBS Primer, 1999). Modernization planning is a continuous effort that is utilized to produce inputs for the formulation of the Program Objective Memorandum (POM). The POM is the culmination of the planning and programming phases of the PPBS. Figure 5 provides an overview of the major components of the PPBS.

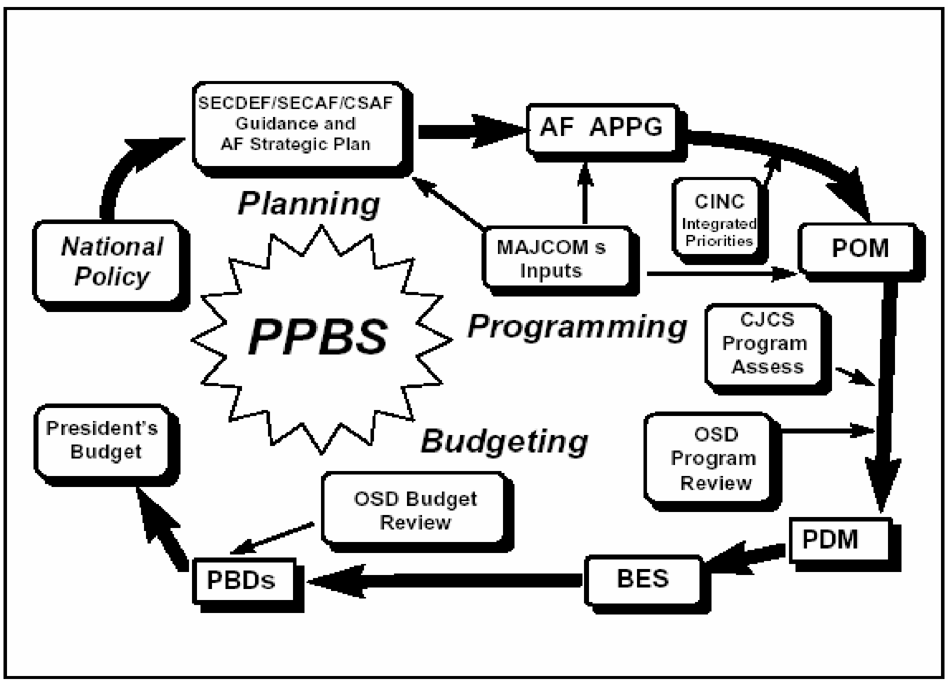

Figure 5. The PPBS (PPBS Primer, 1999)

Modernization is a difficult task to accomplish due to an environment of constrained resources. There has been a steady decline in DoD and Air Force modernization funding since the mid-1980s (Ellet, 1998). The issue of limited funding dictates that the Air Force successfully leverages technology to realize capability

improvements (Aguilar, 2002). This creates the demand for comprehensive planning that maximizes the capability provided to the end user for the money spent.

The focus on capabilities with regards to modernization and transformation stems from the effort to reengineer the Air Force Resource Allocation Process (AFRAP). The AFRAP reengineering effort centers on the creation of a capabilities framework that will be used in modernization planning and resource allocation decisions (Lorenz, 2001b). This is a dynamic process intended to shape modernization efforts Air Force wide in the future.

One attempt at AFRAP transformation is the ongoing creation and use of the Task Force CONOPS (Stevenson, 2002). The creation of task forces corresponding to Air Force mission areas is intended to develop capability sets for each area. The vision of the Air Force Chief of Staff is having capabilities driving the budgeting process (Stevenson, 2002).

Modernization planning is one part of the overall Air Force strategic planning process. Figure 6 shows a more in depth look at the relationship between the MPP and AFSP. One important aspect of current MPP that is displayed in Figure 6 is the role of the MAJCOM. The planning process is decentralized with most of the planning being conducted primarily at the MAJCOM level (Eidsaune, 2000). The MAJCOM planning inputs are combined to formulate the USAF budget submission. MAJCOMs utilize a standard Air Force modernization planning process.

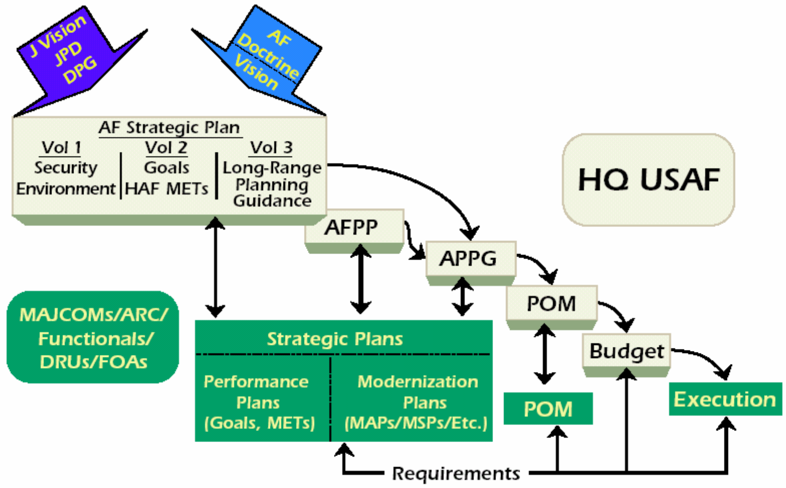

Figure 6. The Air Force Strategic Planning Process (AFSP, Vol. 3, 2000)

The Air Force Modernization Planning Process (MPP) consists of three steps that generate outputs used to produce modernization plans. The three steps are the Mission Area Assessment (MAA), Mission Needs Analysis (MNA), and the Mission Solution Analysis (MSA). These three steps facilitate the creation of Mission Area Plans (MAPs) and Mission Support Plans (MSPs). The MPP process is conducted over a two year period allowing synchronization with the PPBS (AFI 10-601, 1999). The process is conducted by Mission Area Teams (MATs) located at MAJCOMs, Field Operating Agencies, and Direct Reporting Units responsible for modernization planning.

The first step, MAA, consists of transforming military strategy and guidance into tasks. These tasks are determined to be necessary to accomplish the prescribed military objectives. The next step, MNA, evaluates the ability of the current force to accomplish the tasks identified during the MAA. This step results in a list of capability shortfalls to be addressed through modernization solutions. The final step, MSA, identifies potential material solutions intended to fix the capability shortfalls. A material solution is identified as something other than a change in tactics, doctrine, training, or strategy (AFI

10-601, 1999). The MSA step yields a list of prioritized solutions that address the capability shortfalls identified.

The results of the first three steps of the MPP support the creation of MAPs and MSPs. These plans act as a "modernization roadmap" for the next 25 years (AFI 10-601, 1999). Specific fighter and bomber roadmaps are produced in addition to the mission area roadmaps. All of these modernization plans flow into the Air Force Program Projection (AFPP) which serves as a mid and long term investment plan. A depiction of the MPP, to include inputs, outputs, and process flow, is provided in Figure 7.

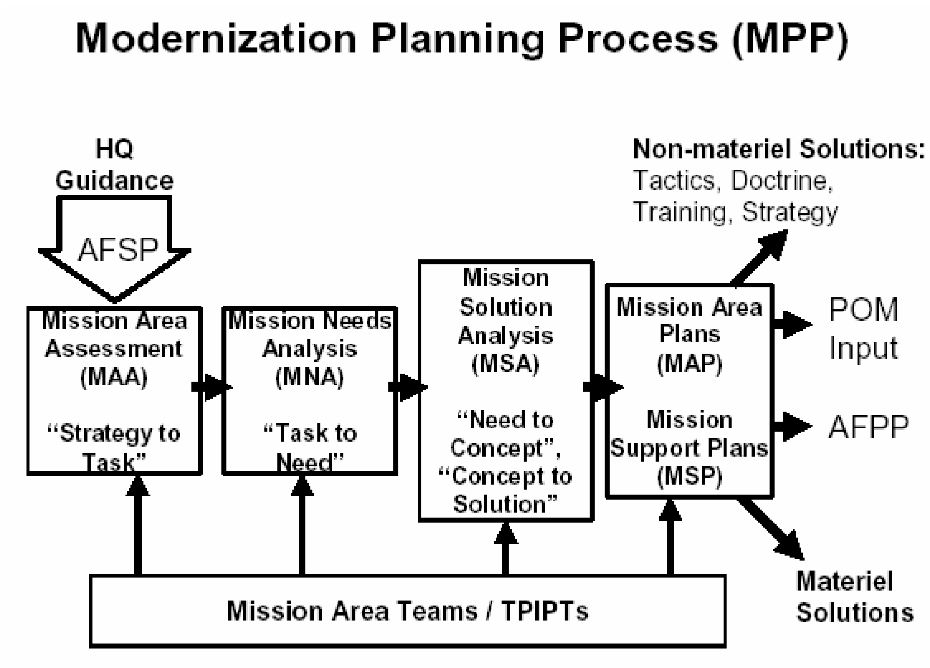

Figure 7. MPP (AFI 10-601, 1999)

ACC utilizes the Air Force MPP to identify and address capability shortfalls for the combined Combat Air Forces (CAF). "ACC is the lead for the modernization of all fighter, bomber, search and rescue, and non-space Command and Control (C2) and Intelligence, Surveillance and Reconnaissance (ISR) forces" (ACC Strategic Plan, 2002:8). A detailed depiction of the ACC MPP, to include the sources of guidance,

mission considerations, and feedback sources is provided in Figure 8. ACC conducts both qualitative and quantitative analysis during the MPP development. One quantitative method that is utilized by ACC is multi-objective decision analysis.

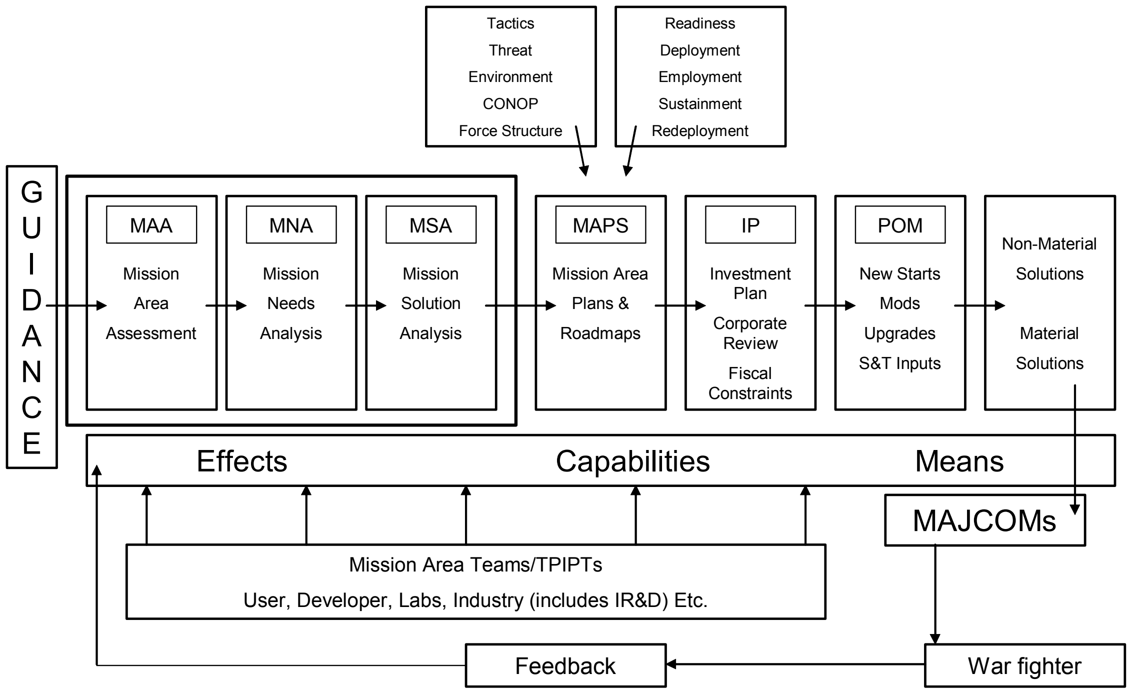

Figure 8. ACC MPP (Sullivan, 2002)

Multi-Objective Decision Analysis

Multi-Objective Decision Analysis (MODA) is a method of providing structure to complex decision problems with multiple evaluation criteria. The application of MODA can provide quantitative decision tools that are defendable, repeatable, and objective (Chambal, 2002). Numerous methods of conducting MODA have been developed. Different MODA approaches include Value Focused Thinking (VFT), Multi-Attribute Utility Theory (MAUT), the Analytic Hierarchy Process (AHP), and Multiple Criteria Decision Making (MCDM) (Kirkwood, 1997). All of these techniques attempt to provide structure to decision problems in their application.

The techniques differ in their means, but all result in information intended to assist decision makers. These techniques provide insight and analysis, not full proof answers to decision problems. The structure, repeatability, and objectivity of these techniques make them ideal for use in modernization planning and the AFRAP.

Modernization Utilizing MODA

The use of MODA for the purpose of modernization planning has become wide spread throughout the Air Force and DoD. There are numerous examples that demonstrate the applicability of MODA techniques to the difficult resource allocations problems that face defense leaders. The examples that follow do not represent a comprehensive list, but rather a few notable uses of MODA in the DoD.

One popular application is the Foundations 2025 value focused thinking model created to evaluate air and space dominance in the year 2025 (Parnell, 1998). In regards to modernization, this model was used to evaluate futuristic system concepts and technologies. This model development provided an example for the use of MODA towards complex defense decisions.

In response to the AFRAP initiative, USAFE created a resource allocation model (RAM) utilizing MODA techniques. The USAFE RAM is a capabilities based model intended to "link resource allocation to strategic planning and performance management" (Lorenz, 2001a). The USAFE RAM utilizes a hierarchical structure consisting of capabilities, mission essential tasks, programs, and measures (Lorenz, 2001a). This MODA tool is intended to allow a decision-maker the ability to balance capabilities over time (Lorenz, 2001a).

The Army conducted modernization planning for the utility helicopter fleet by using MODA techniques. The focus was to maintain capability by integrating MODA techniques with general qualitative methods and cost analysis. MODA was one part of an analysis that included platform evaluation and fleet mixture analysis resulting in a fleet modernization strategy and implementation plan (Prueitt, 2000).

MODA was utilized by the Air Force Studies and Analysis Agency (AFSAA) to conduct an analysis of alternatives for a next generation of gunship. A value focused thinking model was created with the goal of screening alternatives that could replace the current AC-130 Gunship (Renfro, 2002). This information was utilized in congruence with information provided by an independent contractor to evaluate the most appropriate alternatives for future investment.

In 1999, a joint sponsored effort by ACC and Air Force Space Command (AFSPC) was undertaken to improve the implementation of the MPP. This effort was labeled the Aerospace Integrated Investment Study (ASIIS) and included a MODA model to address a standardized capability framework (ASIIS, 2000). “The primary purposes of ASIIS are to standardize the analysis used to implement the MPP at ACC and AFSPC and to rectify deficiencies in their existing analytical approaches” (ASIIS, 2000:1). This effort resulted in an initial model, based on capabilities, providing an example for both ACC and AFSPC to follow.

AFSPC has incorporated the results of ASIIS into an integrated planning process (IPP) which “underpins AFSPC’s responsibilities to equip the Air Force with the space portion of aerospace power” (Space IPP Handbook, 2000). AFPSC utilizes a value model to evaluate capabilities as part of the overall IPP. Analogous to the AFSPC effort,

ACC has applied MODA to modernization planning in attempt to improve resource allocation.

Combat Air Forces Planning and Programming Analytical Tool

The ACC Directorate of Requirements (DR), Analysis Division (DRY), Resource Analysis Branch (DRYR), is charged with providing CAF senior leadership with an objective, analytically developed assessment of operational and tactical level capabilities and shortfalls. This assessment is to be used to evaluate operational and tactical capabilities, solution to needs analysis, and the return on investment of solutions (ACC/DRYR web page, 2002). This fits into the mission of ACC/DR providing "better definition for modernization and sustainment of weapons systems" (ACC/DR Goal web page, 2002). In an attempt to meet this requirement, ACC/DRYR, in a combined effort with ACC/DRPX, created the CAFPPAT.

The CAFPPAT is a MODA tool intended to assist in difficult modernization decisions. "It is a tool that is applicable for a given period of time across a given set of scenarios to help achieve a desired set of effects using improvements or modifications to a baseline set of capabilities" (Titus, 2002a:2). The key components of this model are the scenarios, campaign level capabilities, and aircraft/system level capabilities.

These components are arranged in a hierarchical model using the multi-attribute utility theory form of MODA. The result of this hierarchical structure of components is a score for material solutions in terms of mitigating capability shortfalls. An overview of the CAFPPAT is provided in Figure 9. Specific levels of this hierarchical model will be

addressed in the following sections and an example of how a solution flows through the model will be diagramed.

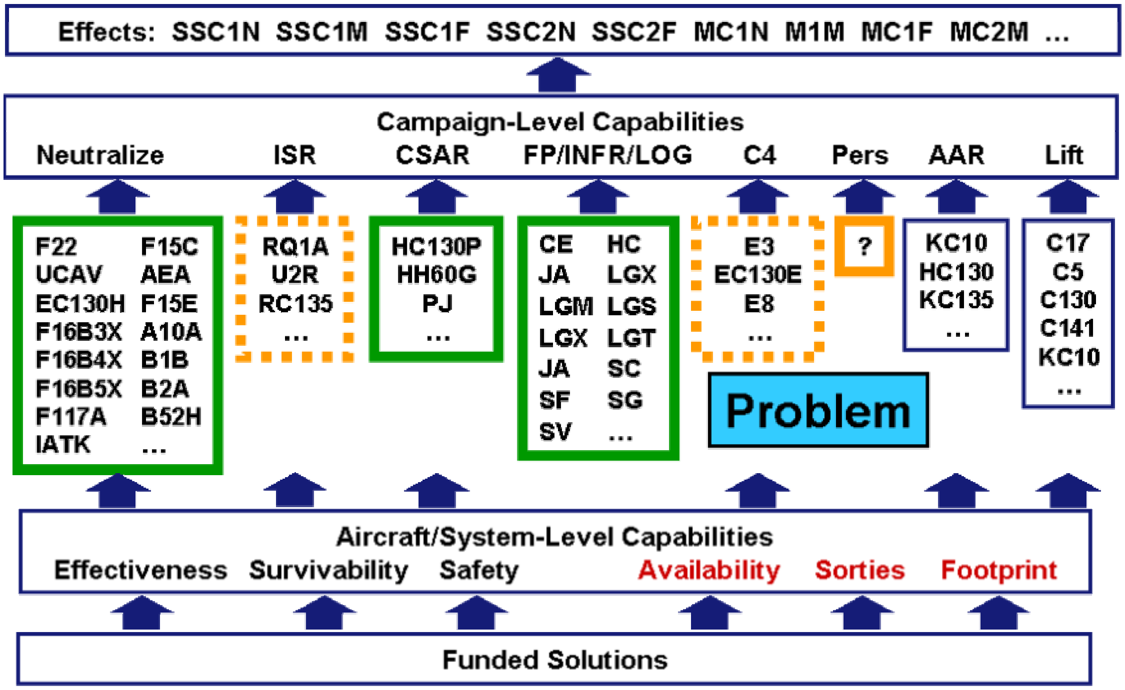

Figure 9. CAFPPAT Overview (Hickman, 2002b)

The model follows the MPP in assessing the capability shortfalls of the CAF and the scoring of potential solutions. "The primary goal of CAFPPAT in ACC/DR is to provide the analytical underpinnings for the MAA, MNA, and MSA, which feed the creations of MAPs for specific mission areas over a 25-year period" (Titus, 2002a:5). Figure 10 displays the CAFPPAT process broken into seven steps and how each part fits into the MPP structure.

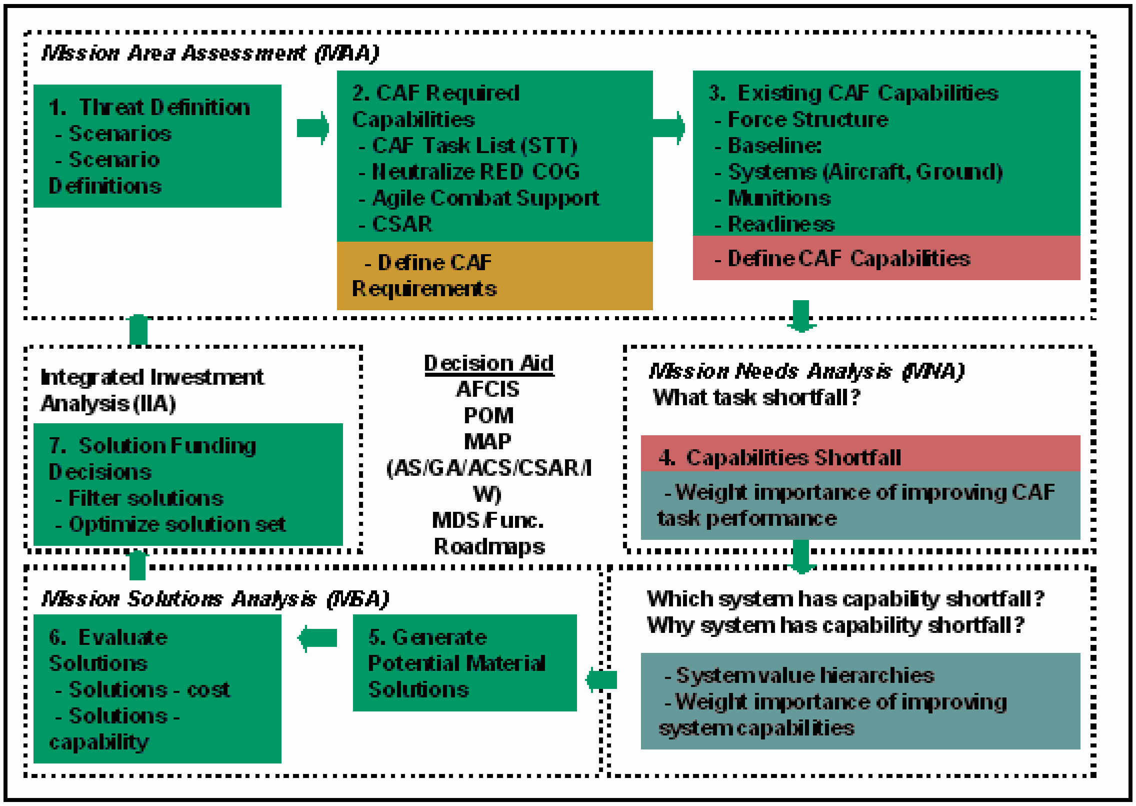

Figure 10. CAFPPAT Process (Hickman, 2002b)

The CAFPPAT represents three dimensional planning and programming based on capabilities, systems, and threats. Capability based planning cannot function independent of the systems that provide the capabilities or the threats the capabilities are required to counter. These three dimensions must be considered and are not mutually exclusive in modernization planning (Hickman, 2002b). One application of the CAFPPAT has been completed by ACC/DRYR and ACC/DRPX in support of the Fiscal Year (FY) 2004 POM. The following sections outline the CAFPPAT components and process as they were developed for the FY2004 POM application. The CAFPPAT is a dynamic tool that is continually being improved to better satisfy its intended use.

Model Assumptions.

In the application of MODA, numerous assumptions are made to facilitate the creation and use of decision models. The most critical assumptions made for the CAFPPAT deal with force structure, scenario coverage, and capabilities. One assumption is that an expeditionary force is necessary to participate in the scenarios chosen (Sullivan, 2002). The chosen scenarios are assumed to accurately portray the most probable future conflicts and needed capabilities. Finally, the hierarchies created for the model are assumed to be collectively exhaustive, mutually exclusive, preferentially independent, and contain the minimum number of objectives possible (Sullivan, 2002). These assumptions are made based on extensive research and coordination with SME.

Scenario Definition.

The first step in utilizing the CAFPPAT is to define a set of scenarios. These scenarios provide the basis for determining what tasks the CAF need to accomplish in order to achieve the desired effects. Scenarios are developed based on Defense Planning Guidance (DPG) and other sources of national military strategy. Another contributing factor in building scenarios is the availability of data from sources such as the Modernized Integrated Database (MIDB). The data is critical because it increases the objectivity and accuracy of the model. The scenarios chosen for use in the CAFPPAT can occur anytime during the next 25 years and can be any type of known conflict.

Once a time frame and type of conflict is chosen, 19 different variables are considered to further define the scenarios. These variables represent likely conditions and are necessary to assess the operating environment. Once a type of conflict and

timeframe has been chosen, the 19 variables remaining result in over 3.8 billion possible scenarios. This demonstrates the ability of CAFPPAT to capture the specifics involved in a possible conflict.

The first application of the CAFPPAT utilized four scenarios. These scenarios were chosen based on their congruence with the DPG and availability of data (Sullivan, 2002). These four scenarios represent a sample of probable conflicts based on DPG and national military strategy. The credibility of the CAFPPAT is increased with the inclusion of more scenarios, such as homeland defense, in future applications of the model (Hickman, 2002b).

The four scenarios chosen represent the top branch of the hierarchical MODA model. The scenarios are weighted equally based on the assumption of the model designers. The assumption is that the CAF need to modernize for each of these scenarios is equivalent (Titus, 2002a). Each scenario will have its own hierarchical structure representing needed capabilities and CAF ability to achieve the necessary effects. This concept is displayed in Figure 11 with notional scenario examples. Once again, each scenario represents one branch of the MODA model.

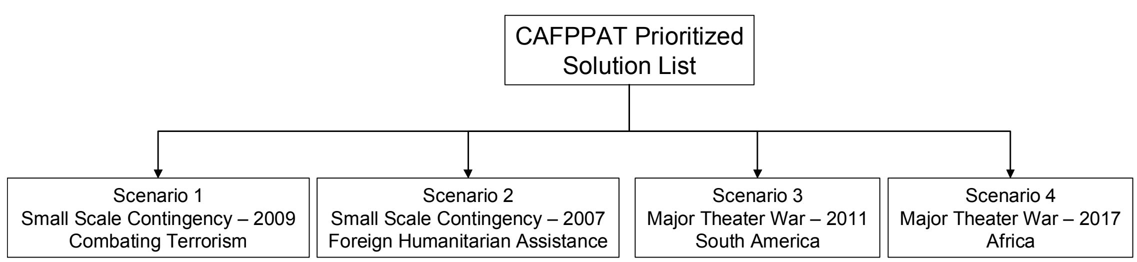

Figure 11. CAFPPAT Scenario Structure

Campaign Level Capabilities.

Campaign level capabilities represent the effects that need to be achieved for each scenario. CAFPPAT is designed to address seven different mission areas that ACC is responsible for modernizing. These mission areas directly correspond to four analytical capability areas that were created by the CAFPPAT designers. The capability and corresponding mission areas are displayed in Table 1.

Table 1. Capability and Mission Areas

Capability Area	Mission Area
Neutralization	Global Attack Air Superiority Information Warfare
Force Protection/Infrastructure/Logistics (FP/INF/LOG)	Agile Combat Support Information Warfare
Combat Search and Rescue (CSAR)	CSAR
Intelligence, Surveillance, and Reconnaissance (ISR)	ISR
Command and Control	C^2

Task lists have been created for all five of the campaign level capability areas. The five task lists represent the specific tasks that need to be accomplished to achieve success in that particular mission area. Each task list is a hierarchical structure providing the appropriate level of detail such that the tasks can be understood and compared (Hickman, 2002b). There are separate task lists for neutralization, combat search and rescue (CSAR), force protection/infrastructure/logistics, command and control, and intelligence/surveillance/reconnaissance (ISR). The task lists were created from Volume 3 of the AFSP, existing operation plans, CONOPS, and Air Force and Joint task lists (Sullivan, 2002). During the first application of the CAFPPAT, no task list for ISR was created. This task list has since been created and is in the process of verification and validation.

The lowest level of each capability task list is represented by evaluation measures. These measurable tasks are the foundation for the MODA techniques utilized in each of these capability hierarchies. Table 2 provides a list of the capability hierarchies and their respective number of measurable tasks. This provides insight into the large number of capability tasks that are addressed in the CAFPPAT.

Table 2. Capability Evaluation Measures

Capability Task List	Evaluation Measures
Neutralization	151
Combat Search and Rescue	6
Force Protection/Infrastructure/Logistics	309
Intelligence/Surveillance/Reconaissance	136
Command and Control	30

Air to air refueling (AAR) and airlift (Lift) capabilities are notionally included in the CAFPPAT. Modernization planning for these areas is the responsibility of Air Mobility Command (AMC). ISR and Command, Control, Communications, and Computers (C4) are mission areas that are under development for consideration in further applications of the CAFPPAT.

System Level Capabilities.

The system level of the CAFPPAT represents the complex man machines, or weapon system platforms, that are used to accomplish campaign level tasks. "Platforms have inherent capabilities to accomplish tasks. These capabilities are broken down into platform level tasks and are displayed in a hierarchical format similar to the campaign level tasks" (Sullivan, 2002:5). Each platform (aircraft) has a capability hierarchy consisting of the following six task categories; availability, effectiveness, sorties, footprint, survivability, and safety (Sullivan, 2002). The system capability hierarchy used to evaluate each platform has 168 evaluation measures. The lowest level of Figure

12 shows the system level capabilities and the aircraft that are applicable to each campaign level capability.

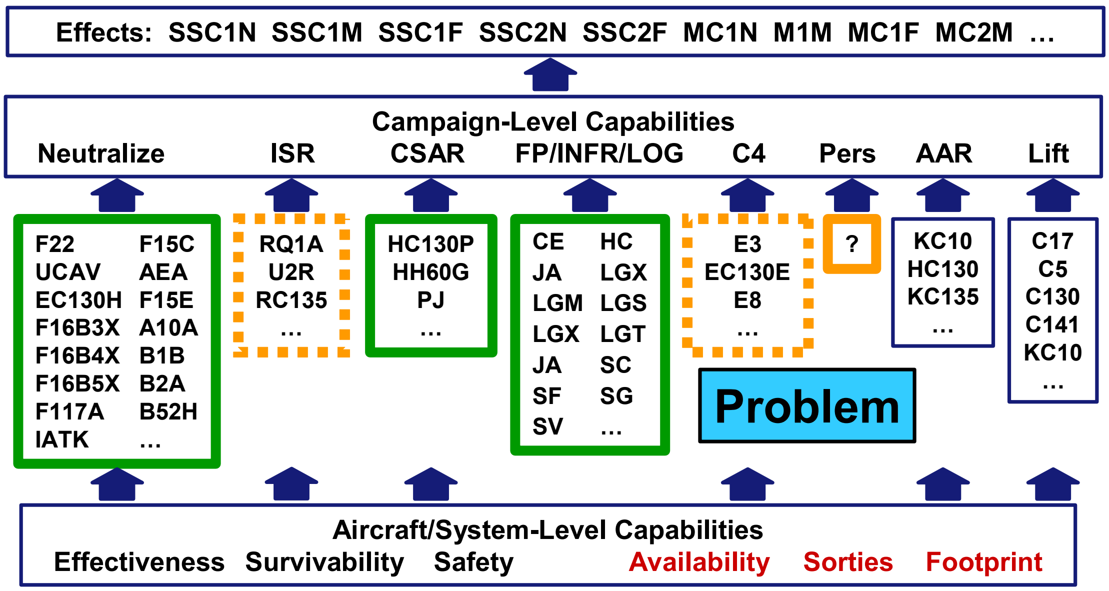

Figure 12. System Level Capabilities (Hickman, 2002b)

CAF Baseline and Contribution Matrix

In order to determine where capability shortfalls exist, the current CAF capability baseline is determined. The CAF baseline represents the current force structure consisting of the available aircraft. This baseline incorporates such factors as "postulated sub-systems, projected mission capable rates, and future availability (due to service life)" (Hickman, 2002b).

The creation of the campaign level task list details what tasks need to be accomplished in the different mission areas to achieve the desired effects for each scenario. However, the CAF may not be capable of accomplishing all of the tasks on the list. Additionally, the CAF will be participating in a joint effort with other services to

accomplish the tasks for each scenario. Therefore, the contribution of CAF for each scenario and task list must be determined.

A contribution matrix allows SME, such as campaign planners, to determine how much of each task should be allocated to each of the appropriate platforms (Titus, 2002a). The CAF baseline provides the allocation limitations for the contribution matrix. When the allocation is complete, the matrix represents how the projected CAF baseline will be utilized to achieve the campaign level tasks.

Needs List Development

The creation of the CAF baseline and contribution matrix facilitates the creation of a campaign level needs lists. This is accomplished through a weighting process in which SME are utilized. Each measurable task in each of the campaign level capability areas is evaluated to identify shortfalls. This is accomplished by having the SME determine how important each task is to improve and how well the CAF currently performs the task. The evaluation scale utilized is shown in Figure 13.

A point estimate is made on the scale for each task on that particular level of the hierarchy. These point estimates are then mathematically evaluated to determine an index representing a quantitative capability shortfall. The index for each measurable task is utilized to calculate the capability shortfall index for each level of the MODA hierarchy.

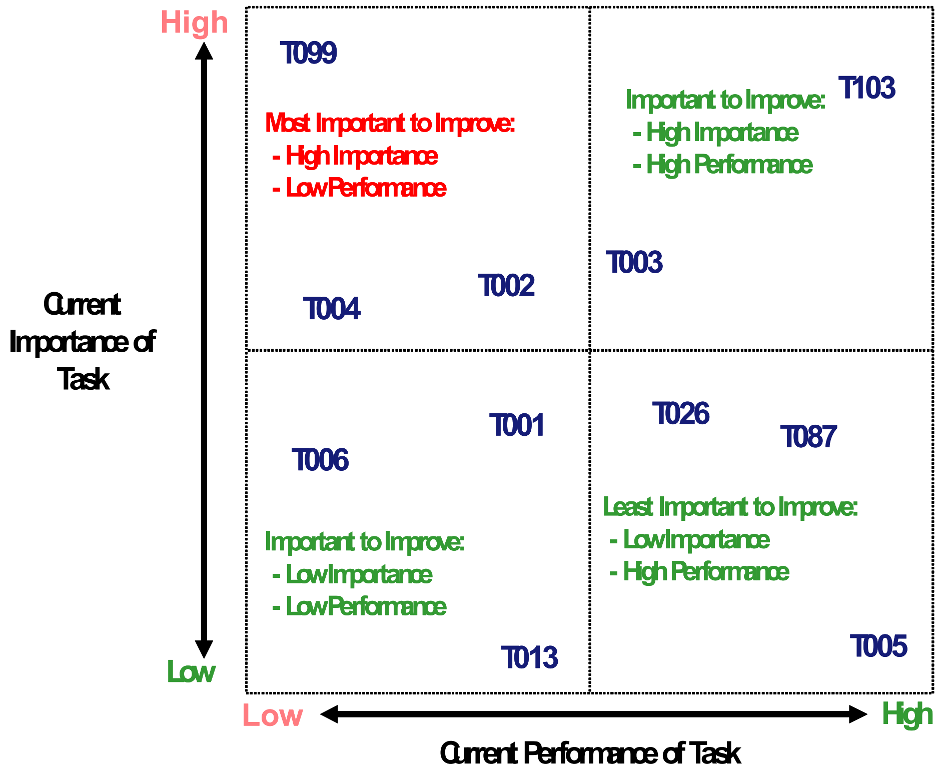

Figure 13. Evaluation Methodology (Titus, 2002)

This mathematical exercise results in a "need score" for each task within each hierarchy (Sullivan, 2002). The prioritization of the resulting scores results in a needs list. The needs list displays the capability shortfalls in prioritized order to improve. The five campaign level needs lists are then horizontally integrated into one list by utilizing the SME for each list (Sullivan, 2002). Each of the individual lists is important for analysis purposes, but an integrated list displays "where the greatest need for improvement lies regardless of the type of task" (Sullivan, 2002).

The system level needs list is created in the same manner as the campaign level needs list. The campaign capability shortfalls are traced to the systems that are allocated to complete the tasks. The contribution matrix acts as a link between the campaign level

capability shortfalls and the systems that need to be improved to mitigate the shortfalls. The measurable tasks within the system level hierarchies are evaluated in the same manner with SME determining the performance and importance (Sullivan, 2002). This process results in needs lists which are then prioritized. "These needs lists will be different for each platform due to the unique capabilities each bring to the fight" (Sullivan, 2002:33). The system level needs lists can be combined to create a complete system list for each scenario or over all of the scenarios.

Solution Scoring

The scoring of potential solutions, in terms of mitigating capability shortfalls, is also accomplished by SME. The most common SME utilized for this step of the process is the Program Element Monitor (PEM). The PEM is the focal point and primary proponent for their particular platform. The scoring of solutions starts at the platform level of the CAFPPAT. The scores that result represent "a percentage improvement to the baseline configuration of the platform" (Titus, 2002a).

Any platform level capability improvement is mathematically transferred to the corresponding campaign level capabilities that it has a direct affect upon. This mathematical roll-up provides a final score indicating how much improvement over the baseline capability each solution provides. This allows solutions to be compared with each other and prioritized. The solutions given the highest priorities represent the largest mitigation of capability shortfalls.

The flow of a potential solution through the different levels of the CAFPPAT is depicted in Figure 14. The solution is evaluated against applicable platforms which then affect certain campaign level tasks. The effect is then rolled up into the applicable

scenarios that rely on those tasks to achieve the desired effects. Figure 14 also displays the capability of the model to generate output at each of the levels.

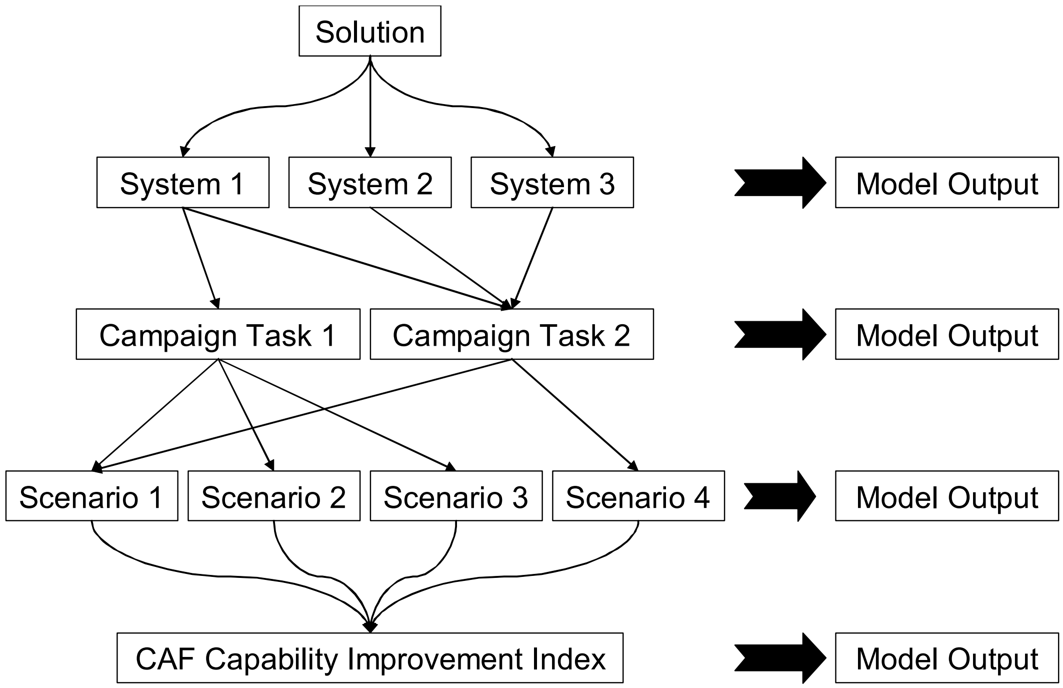

Figure 14. CAFPPAT Solution Flow

CAFPPAT Outputs.

The CAFPPAT is a comprehensive modernization tool that produces a variety outputs that can be utilized for decision support. The list of solutions is the primary CAFPPAT output:

> The chief output of the MPP is a prioritized list of competing solutions to satisfy the needs. Solution lists can be prioritized within a platform or functional area. It can span across platforms to encompass an entire mission area. Finally, the MPP can integrate all CAF solutions into a single prioritized solution list. These lists can be prioritized based on the increase of capability the solution brings. (Sullivan, 2002)

The flexibility in analyzing the prioritized solution list allows CAFPPAT contribution to many different modernization planning efforts.

Other outputs provided by the CAFPPAT are a baseline capability assessment and lists of capability shortfalls at the campaign and system level. These outputs are part of the CAFPPAT process of scoring solutions, but can be useful for analysis on their own. Different CAF modernization planners can utilize these outputs in their own analyses.

A solution-to-need matrix is created upon completion of a CAFPPAT cycle for each platform. "This matrix considers the needs of each platform, prioritizes them by the "need to improve" score and then links competing solutions to the needs they address" (Sullivan, 2002:49). This output provides a way to evaluate the solution list to see if the most critical platform needs are being addressed (Sullivan, 2002). This matrix is particularly useful to the fighter and bomber roadmap planners due to the ability to analyze each platform individually. A visual summary of the outputs discussed is provided in Figure 15.

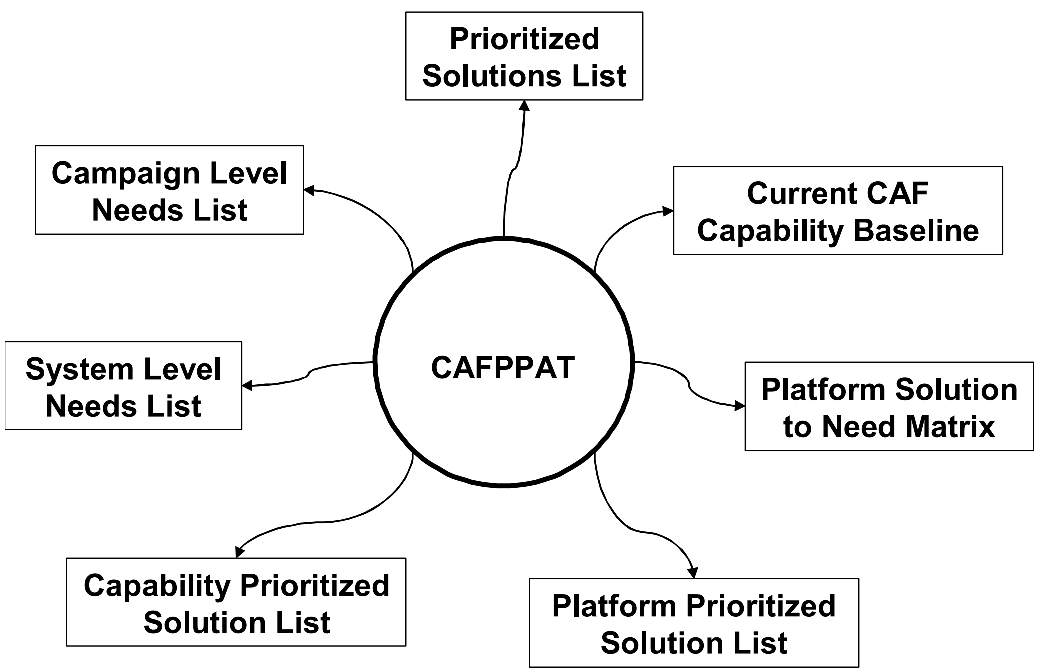

Figure 15. CAFPPAT Outputs

Model Limitations.

There are numerous limitations that were discovered in the first application of the CAFPPAT. Capability areas not controlled by ACC were assumed to be non-limiting in achieving the desired effects (Titus, 2002a). Areas such as ISR and AAR could actual play a role in achieving the desired outcome and need to be incorporated in further uses of the model. The limited number of scenarios evaluated limits confidence that the capabilities addressed are comprehensive. The inclusion of more scenarios will increase the fidelity of the model (Titus, 2002a).

More accuracy is needed in the data used to facilitate the CAFPPAT process. Better data coupled with improved methods of determining the current performance of tasks will increase confidence in the model (Titus, 2002a). The sheer size and complexity of the model makes it difficult to use. A small number of individuals know the process and it consumes a lot of time to complete. Efforts to improve model efficiency and the ease in which it is created are currently being pursued.

The Role of Experts.

A fundamental premise of the CAFPPAT is the reliance upon SME. The SME are used for the actual construction of the model, task weighting, and scoring of potential solutions. ACC/DRYR attempts to obtain the most knowledgeable and experienced group of individuals for each portion of the model where SME are required. In almost all cases, it is more than one SME participating in task list creation, weighting, and solution scoring.

Groups of experts are relied upon for the CAFPPAT due to the time and effort required to complete the modeling exercise. The CAFPPAT is intended to assist senior

Air Force decision makers who are often unable to devote the necessary time to complete the model themselves. Therefore, SME are utilized in place of the decision makers to provide the decision supporting information. Group decision making plays a prominent role in the appropriate use and credibility of the model and its results. The significance of using groups for decision making is not unique to the Air Force. "Decision making groups are pervasive in both the private and public sectors of our society" (Seaver, 1976:1).

Group Decision Theory

"Group decision covers a wide range of collective decision processes and encompasses numerous methods designed under various assumptions and for different circumstances" (Zahedi, 1996:265). In literature, these methods have been classified in different ways based on process mechanics or functional use. Seaver (1976) suggests that the two general procedures for obtaining a group decision are mathematical aggregation procedures and behavioral methods. The aggregation procedures utilize mathematical formulas to reach a group decision while the behavioral methods utilize interaction or communication (Seaver, 1976).

Alternatively, Srisoepardani (1996) classifies group decision methods based on their functional purpose. The methods are either utilized for the structuring, ordering and ranking, or structuring and measuring. Zahedi (1996) proposes the following five categories for classification of group decision methods: group utility analysis, group consensus, group analytic hierarchy process, social choice theory, and game theory.

Finally, Dewar (1996) proposes that the methods can be categorized as statistical group methods, unstructured group interaction, and structured, direct interaction. Statistical group methods tabulate group answers and no interaction occurs. Unstructured group interaction, also known as face to face communication, results in an agreed upon decision. Structured, direct interaction utilizes the benefits of group communication and adds structure in attempt to counter any negative aspects of interaction.

These four classification systems are logical and useful based on the specific requirements of the decision analysis technique being utilized. However, significant overlap exists in the classifications with each system representing a different view of many of the same methods. This research effort is not concerned with determining which method of categorization is correct. Therefore, the review of each method will suggest the different classifications that each method will fall under.

In some group decision literature, creativity techniques are sometimes identified as group decision methods. The brainstorming technique and boundary examination are two examples of idea generation techniques that have been labeled group decision methods. This research effort will only identify and label group decision methods that result in some form of consensus answer.

Group decision methods are just one part of the large field of management science. These methodologies utilize facilitation techniques to varying degrees based on the process involved to provide input into decision analysis techniques. This relationship is represented in Figure 16 and it is not assumed that the three components can be evaluated independent of each other. Facilitation is often a critical part of the group decision methods available and some methods are considered decision analysis

techniques. This blending of components is evident in the decision analysis literature as indicated earlier by the overlapping classification systems.

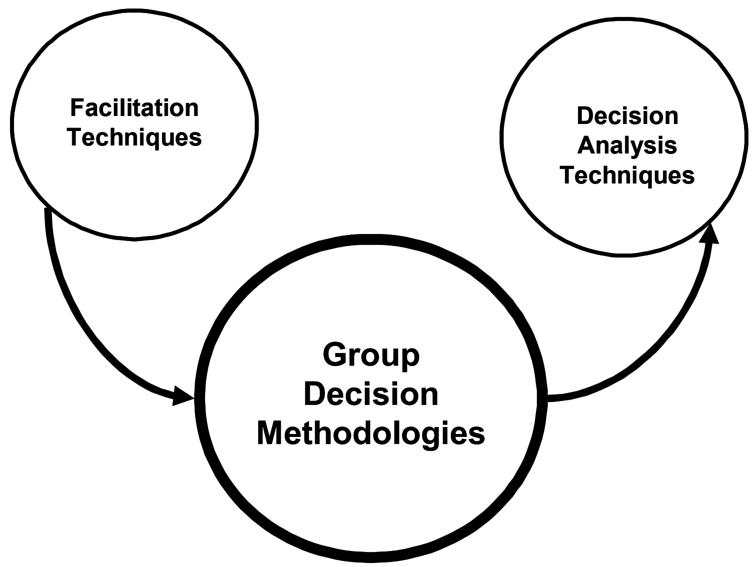

Figure 16. Decision Analysis Components

Group decision methodologies will be reviewed and the role of facilitation will be addressed based on its role in utilizing each method. The group decision methods that can be considered decision analysis techniques will not be included in this review. The analytic hierarchy process identified by Zahedi (1996) as a group decision method, for example, is considered a decision analysis technique (MODA) in the context of this research effort. The focus of this section is to review methods that can provide input into decision analysis techniques. Appendix B provides an exhaustive listing of all the techniques and methods reviewed for this research effort and their subsequent classification for this study.

Research has been conducted for years in the field of group decision theory in an attempt to improve the ability to consolidate the knowledge and experience of experts to

assist in decision making. According to one author, there are many potential benefits in utilizing groups for complex decisions:

> First, groups are more likely than individuals to have a broad and better range of skills and knowledge pertaining to the decision. Second, groups provide the opportunity for an effective division of labor to acquire and process the vast amount of information needed for the decision. Third, when groups are composed of members representing a diversity of interests, the decision is perceived to be more representative of the needs of members. This results in wider acceptance of and greater commitment to the decision. (Bernard, 1995:251)

Alternatively, the use of groups for decision making also comes with issues that hinder the decision analysis process. The issues represent barriers to the effective use of experts in group decision settings. Polarization, risky shift, representativeness, availability, anchoring and adjustment, motivational bias, groupthink, social loafing, and group conflict are all issues that can be labeled group dynamics. These issues fall under the realm of social psychology (Seaver, 1976) and will be addressed tangentially through the review of the different methods. The following sections represent a thorough review of current group decision methods.

Face to Face Group Interaction.

This method of group decision making, in its simplest form, consists of a group of people discussing a decision problem resulting in a consensus answer. Group conflict or disagreement is resolved through discussion and compromise to reach consensus. This method is often recognized as the conventional problem solving group. This is an unstructured method which allows its use for a wide variety of functions. Ranking and selection between alternatives along with idea generation are just a few examples of decision problems that can be addressed with this method. This method is the foundation for all other group decision methods that utilize interaction and communication.

Voting.

Voting is part of social choice theory and "involves selecting an alternative or candidate based on multiple criteria" (Zahedi, 19996:269). "The social choice theory investigates the process of arriving at a group decision in democratic societies through the expression of majority's will" (Zahedi, 1996:269). Voting is made up of the actual process of each individual choosing an alternative and the subsequent aggregation to determine the best choice. The different aggregation techniques are the focus of this method review.

Plurality voting consists of simply counting the first place votes and the alternative with the most is selected. The Borda rule utilizes the average rank value of each alternative to determine which to choose (Chamberlin, 1985). The Borda rule is one form of trimmed mean voter aggregation. The average rank of each alternative is computed and compared for selection. Another form is the trimmed median where for each alternative, the median rank is representative and utilized for selection (Hurley, 2002).

"The Hare system, also known as preferential voting, is a sequential elimination system" (Chamberlin, 1985:196). The votes are counted and the alternative with the majority of first place votes is selected. If this does not occur after the first vote, the alternative with the fewest number of first place votes is eliminated. The process is repeated until the one alternative obtains the majority of first place votes.

The Coombs system is identical to the Hare system except for the methodology used to eliminate alternatives. Under this system, the alternative with the largest number

of last place votes is eliminated. This is done until an alternative carries the majority of first place votes (Chamberlin, 1985).

Approval voting consists of each voter casting either a one or zero for each alternative. An alternative given a one shows approval where a zero shows that the alternative does not measure up for that particular voter. The approval votes are counted and the alternative with the most approvals is selected (Nurmi, 1984).

Finally, cumulative voting allows each voter to cast a certain number of votes. The voter can allocate votes between alternatives in any combination to indicate preference in terms of magnitude (Brams, 2002). The end result is a ranking of candidates upon tabulation of the votes.

Delphi Technique.

The Delphi Technique is a structured, iterative process that focuses on the goal of obtaining group consensus. Delphi was created by the RAND Corporation in the 1950s as a forecasting tool. The intent of creating this procedure was to reduce the negative aspects of face to face group interaction (Dalkey, 1967). Four characteristics are fundamental to the Delphi method and its successful implementation. The foundations of this method are anonymity, iteration, controlled feedback, and statistical aggregation of group response (Rowe, 1999).

According to Zahedi, (1996), there are three steps to the Delphi process to reach a group consensus answer. The first step is to design a survey that addresses the problem and then have each group member respond individually to the survey as the second step. The third step of the process is to analyze the results, adjust the survey where needed, and

provide aggregate results to each individual for their feedback. A sufficient number of iterations of these three steps should be completed until a consensus answer is reached.

"This widespread use of the Delphi Technique has led to many variations in format and implementation among practitioners" (Erffmeyer, 1986:121). According to Rowe (1999), a classical form of Delphi consists of the first round being unstructured with inputs regarding the problem being solicited from experts. The following rounds are structured with statistical feedback being provided to the participants.

Common Delphi utilization has the first round of the procedure structured to make it easier on the facilitator. The number of rounds used is variable, but the total rarely exceeds two (Rowe, 1999). The optimal number of rounds to be conducted was researched by Erffmeyer (1986) and concluded to be four rounds. Additionally, the experts are usually only tasked to provide one statistic as an input into the process for simplification purposes (Rowe, 1999).

Nominal Group Technique.

The Nominal Group Technique is another structured group decision method that was created by Delbecq and Van de Ven in 1971 (Zahedi, 1996). This method is similar to the Delphi method in attempts to utilize the benefits of collective group expertise while countering the negative aspects of group interaction. "The object of the method is to offer a non-conflictual process for arriving at creative, non-routine decisions" (Mahler, 1987:337). Contrary to the Delphi method, anonymity is not part of the process and group members are assembled together. Additionally, this method of group decision making requires an active leader (Seaver, 1978).

In its original form, this technique consists of six steps that follow the clear definition of the problem being presented to the group (Bartunek, 1984). The first step is to have each group member silently generate ideas and write then down. The second step is to have the facilitator record all of the ideas in a round robin fashion until all are listed. Third, each idea is discussed until everyone in the group understands them fully.

The fourth step requires each group member to secretly rate the alternatives and the facilitator records the votes for group review. The group then discusses the vote just taken to further clarify issues. The sixth and final step consists of iterations of secret votes and discussion until a clear choice is identified (Bartunek, 1984).

Group Utility Analysis.

This is a statistical method used to mathematically aggregate the utilities of each individual within a decision making group. The method is based on the assumption that the utilities of each member are independent (Zahedi, 1996). The individual utilities are combined by an additive or multiplicative function that includes variables such as weights and scaling constants. Methods such as the delegation process and Brock method have been created to address the assignment of weights to the utility functions of the group members (Zahedi, 1996).

The result of this method is a group utility function that addresses the question of interest. This utility function can be utilized to rank alternatives and select the one that maximizes utility for the group. This method is mathematically intense and requires the estimation of individual utility functions for all of the group members. There is no requirement for the group members to meet or interact to use this method. This method does require the use of a facilitator trained in mathematics, statistics and utility theory.

Krzysztofowicz Group Consensus Method.

This group decision method is similar to the group utility analysis by mathematically combining the preferences of the individuals in the group. The goal is a group consensus function that represents the consolidated preference of the group. It is different because individual utility functions are not required and a group consensus function may not be determined (Zahedi, 1996).

This method utilizes subgroups representing different expertise that are utilized to estimate different marginal utility functions. These marginal utility functions represent attributes of an overall group utility function. These marginal utility functions will then be combined by an additive or multiplicative function. The result is a collection of consensus points for the group that can be used to create a consensus function. This method focuses on combining preferences based on attributes decomposed from a theoretical group utility function. This method is mathematically rigorous and requires the use of trained facilitators.

Zahedi Group Consensus Method.

The Zahedi method is similar to the Krzysztofowicz method in that it generates points and a function to represent the group consensus. This method creates a consensus value for all of the alternatives under consideration. "In the Zahedi method, consensus values and the consensus function are obtained directly from the preference responses of members. It does not assume the existence of utility axioms and does not require members' utility estimation" (Zahedi, 1996:267).

Each group member provides an interval score for each alternative under consideration which is used to calculate the mean and standard deviation. The computed

statistics are then used to determine the correlation between group members. The next step is to create a covariance matrix for each alternative which is then used to calculate the weight for each alternative for each member. The final step is to compute the consensus point for each alternative by combining the calculated mean and weight.

"The consensus point could be used directly for selecting the alternative with the highest consensus value" (Zahedi, 1996:267). A regression analysis utilizing consensus points and attributes will provide a consensus function for the group (Zahedi, 1996). It is clear that this method is mathematically rigorous and requires trained personnel.

Weighted Linear Combinations.

The method of weighted linear combinations utilizes individual probability distributions aggregated into a group probability distribution. This method has been labeled the "opinion pool" and is utilized for both discrete and continuous distributions (Seaver, 1978:9). This method attempts to identify the experts within a group and provide a higher weight to their particular probability distributions when aggregating for the group distribution (Seaver, 1976).

There are numerous methods available to determine the weights that should be used to aggregate the individual probability distributions. According to Seaver (1976), the weighting scheme utilized has no impact on the quality of judgment produced. This method assumes that the most knowledgeable experts can be identified and that the facilitators are skilled in mathematics.

Aggregation Using Conjugate Distribution.

This method also attempts to combine individual probability distributions into a group probability distribution. This method assumes that the distributions obtained from

individuals are all from the same conjugate family of distributions. "The group probability distribution is determined by successive applications of Bayes' Theorem using all individually assessed distributions" (Seaver, 1976:33). The individual probability distributions are weighted for aggregation similar to the weighted linear combination method.

The Expert Use Model.

The expert use model combines individual probability distributions through a complex mathematical procedure. According to Seaver (1976), the individual distributions are multiplied by a calibration function to turn them into likelihood functions that are combined using Bayes' Theorem. The calibration function serves the purpose of eliminating bias and is different based on whether or not the individual probability distributions are independent. This model is only usable if the individual probability assessments are independent (Seaver, 1976).

The Probabilistic Approach.

Similar to the expert use model, the probabilistic approach differs only in the use of conditional probabilities. Individual probability assessments and Bayes' Theorem are utilized in the same manner to obtain a group probability distribution. However, the probabilistic approach is concerned with the probability of an event occurring given the subjective distribution determined by each individual in the group (Seaver, 1976). This is different from the expert use model which utilizes the probability of a subjective distribution given an event. Like the expert use model, this approach can only be used if the individual distributions are independent (Seaver, 1976).

Cooperative Game Theory.

This group decision method concerns the cooperation of two or more individuals, called players, in attempt to maximize their own gain. "In practice, the players often solve some optimization problem or consider some non-cooperative game in order to arrive at the amount of additional value available from cooperation" (Lucas, 1996:244).

Complex math is utilized to obtain solutions for cooperative games. Three different approaches that are utilized to obtain a solution are the core, nucleolus, and the Shapely value (Lucas, 1996). Cooperative game theory, like many of the methods presented, requires the use of involved mathematics and trained facilitators.

Chapter Summary

In this chapter, the relationship between transformation, modernization, and the use of MODA for modernization planning has been established. The first objective of this research effort has been accomplished through the discussion of the CAFPPAT. The role and significance of experts and group decision making is demonstrated from the CAFPPAT review. Finally, current methods for obtaining a group decision from collective experts were reviewed. This review of these methods will facilitate the selection of methods applicable to MODA models such as the CAFPPAT.

III. Methodology

Chapter Overview

The first objective of this research effort, documentation of the CAFPPAT, was accomplished in chapter II through literature review and analysis. The second objective of this research, and the focus of this chapter, is to identify the group decision methods that are applicable to MODA. This includes the group decision methods that produce consensus inputs which can be utilized for the structuring, weighting, and scoring accomplished in MODA models. The result of this effort will be a taxonomy table that can be used as a reference for evaluating group decision methods for MODA models.

Methodology Construction

The methodology of this study is to map the applicable group decision methods to criteria or driving questions that would dictate their use in MODA. Chapter two provided a list of methods that will be evaluated for use in MODA. This will be accomplished through the review of literature that documents the strengths, weaknesses, and the appropriate uses of each technique. The different decision contexts and settings that are possible in MODA will be incorporated. The result of this mapping effort will be a taxonomy that will be displayed in table format.

The resulting table is intended to serve as a reference for decision analysts to evaluate what group decision making method would be applicable to their particular MODA effort. The table attempts to bridge the gap between usable group decision methods and MODA. At a minimum, the resulting table will represent a first effort at

identifying methods applicable to MODA which can later be improved and expanded. A visual representation of this methodology is provided in Figure 17.

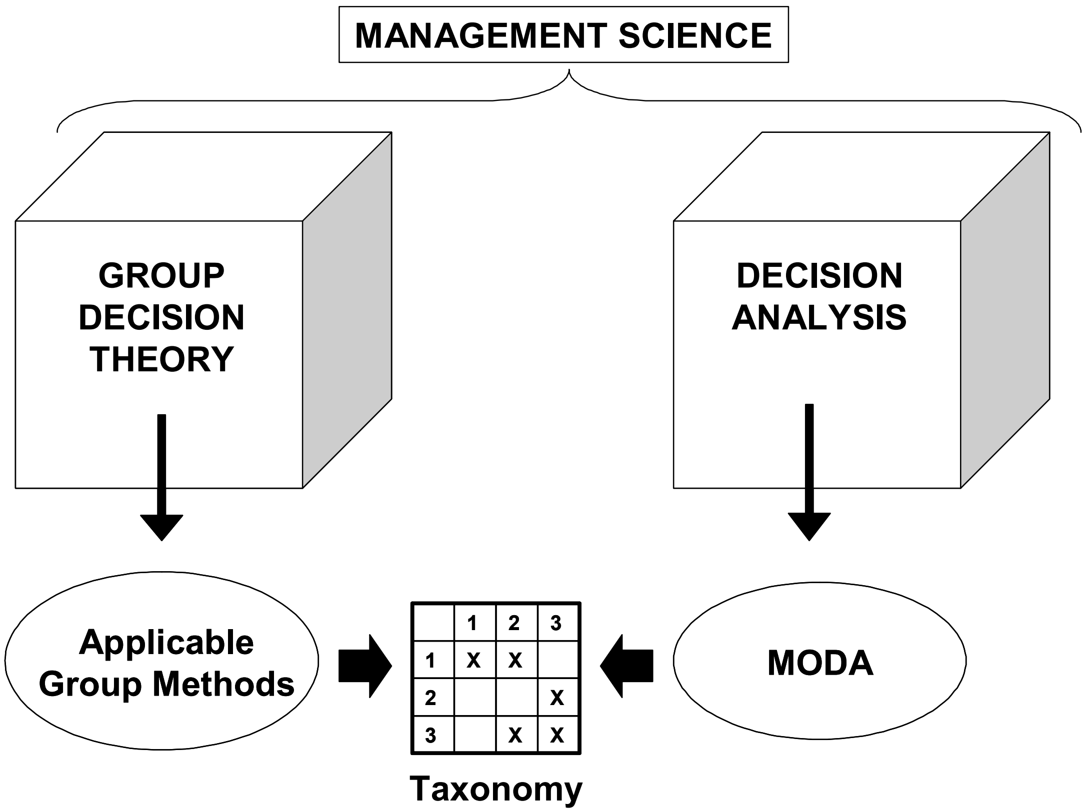

Figure 17. Methodology Overview (Greiner, 2002)

The table will then be utilized to satisfy the third objective of this research effort concerning the CAFPPAT group decision process. The observed CAFPPAT process will be compared to the table in order to conduct analysis and provide insight. Ideally, the insight provided will assist in improving the CAFPPAT process.

Group Decision Methods Applicable to MODA

In order to determine the group decision methods that are applicable to MODA, a few key assumptions have to be made in terms of the MODA environment. These

assumptions are based on the observed CAFPPAT environment at ACC that will be described in Chapter 4. These assumptions are limiting factors, but not restrictive enough to jeopardize the use of the taxonomy table in other MODA settings. These assumptions will provide a baseline to evaluate the group decision methods. The assumptions are as follows:

1. Limited time exists to complete the MODA.
2. There are a limited number of analysts/facilitators available capable of utilizing complex methods.
3. Resources such as experts, facilities, and tools may be limited.

These conditions are restrictive, but they reflect the reality of many organizations that would utilize MODA. Organizations that do not have these restrictions will still be able to utilize the information presented in the taxonomy table.

Based on the assumptions identified and literature reviewed, four of the group decision methods presented in chapter two are applicable to MODA. These methods are face to face group interaction, voting, Nominal Group Technique, and the Delphi Technique. However, as previously noted, voting can take on many forms based on the aggregation procedures used. The other three methods identified incorporate voting as part of their statistical aggregation process. The type of voting method to use in face to face interaction, Nominal Group Technique, and the Delphi Technique is the subject of separate research. Therefore, voting will be excluded from the taxonomy created in this research.

All of the other methods described in chapter two have been excluded from the taxonomy table. These exclusions have been made based on the time requirement,

resource requirement, or method rigor and complexity. Given a different set of assumptions, these methods may be applied to expand and improve the taxonomy. The following sections review the positive and negative aspects, applicability, and appropriate use of the three methods selected. One point that is critical to all three of these group decision methods is the quality of the decision obtained is based on the quality of experts utilized.

Face to Face Group Interaction.

Face to face group interaction is the meeting of a group of individuals with the intent of reaching a consensus group answer. The major premise behind this method of group decision making is that a group of experts are more likely to generate a better decision than a single individual. Consensus answers are obtained through communication of ideas and opinions with compromise eventually providing a solution. According to Hornsby (1994), "consensus is reached when all group members accept the final decision".

Face to face interaction is flexible enough that it can be applied to all areas of MODA. Groups using this method can structure models and utilize any of the different weighting schemes used in MODA. Additionally, the ranking or scoring of alternatives can also be accomplished.

This method allows communication and interaction providing the free flow of information and ideas. Additionally, it provides experts with a sense of participation in the process. Research conducted by Mahler (1987:340) demonstrated that face to face group members felt they were able to "express their views" more than in structured interaction methods. Roth (1995) found that many experts "are not satisfied by a meeting

process without face to face interaction". Additionally, Miner (1979) discovered that greater acceptance of the decisions generated was obtained from this method when compared to the nominal group technique and the Delphi technique.

According to Dewar (1996), face to face interaction faces the problems of influence from dominant individuals, irrelevant conversation, and pressure for conformity. Individuals can influence and dominate the interaction between experts which, in turn, can affect the consensus answer obtained. Irrelevant conversation can lead to the formulation of a consensus decision taking longer than necessary. Group pressures to obtain a solution in an expeditious manner may cause some ideas or alternatives to be overlooked. The use of a neutral facilitator that maintains the focus of the group and helps to resolve conflict improves the overall efficiency of the method.

The larger the group, the more potential for conflict, disagreement, and increased time to reach a consensus answer. Although it is possible to accomplish this method with large groups of experts, the appropriate minimum number of experts to reach a quality consensus answer should be sought. Additionally, it is possible that a consensus answer cannot be agreed upon through this method. This situation requires utilization of another technique or decision analysis tool in attempt to resolve the conflict.

Nominal Group Technique.

The Nominal Group Technique is another group decision method that is applicable to all areas of MODA. This method was created to "take advantage of the known superiority of group processes while eliminating the detrimental effects" (Seaver, 1976:43). Although participation is not anonymous, group pressures are countered through structured discussion and secret voting.

The benefits of utilizing the Nominal Group Technique as a group decision making method are numerous. The method balances the participation and influence of the experts, produces more ideas than interactive groups, and results in satisfaction for the group members (Dunham, 2002). Seaver (1976) indicates that the level of satisfaction obtained from the Nominal Group Technique is greater than face to face and Delphi groups which were equivalent. Additionally, the method reduces the need to conform, de-personalizes the issues, and provides a sense of accomplishment (Dunham, 2002).

The method is not intended to take a substantial amount of time to reach a group decision. However, due to iterations of idea generation, discussion, and voting, there is a possibility for long group meetings. "The mechanics of the technique can, on occasions, become burdensome as it may take considerable time to list all of the participants' ideas" (Chapple, 1996). The issue of group size also impacts that amount of time it takes to complete the process. The more experts that are used, the longer the process will take. This leads to the questions of optimal group size for the technique.

Research on the issue of group size in regards to the Nominal Group Technique provides mixed conclusions. According to Fiedler (1998), "to operate effectively the nominal group technique should be small so that each participant can view the other". However, research conducted by the founders of the method suggests that the number of experts does not have to be limited to a low number. "Nominal group processes can accommodate large numbers of participants without the dysfunctions of conventional discussion involving many participants" (Van de Ven, 1971). This information leads to

the conclusion that the technique will accommodate large numbers, but will be effective and easier to facilitate with a smaller group.

The Nominal Group Technique requires an experienced and competent facilitator in order for it to be successful (Fiedler, 1988; Anderson, 1990). This is critical because research has been done indicating that the facilitator can impact the data collection portion of the process. Chapple (1996) discovered that group participants may not participate fully or be truthful based on the actions of the facilitator.

There is some preparatory work that must be accomplished to utilize the technique. Sufficient facilities need to be obtained that can seat the group and the necessary supplies need to be provided (Dunham, 2002). Additionally, an opening statement should be prepared to focus the group on the problem and elicit their full effort (Dunham, 2002). This opening statement should educate the experts on the problem enough that they can make sound decisions.

The idea that a decision obtained from the Nominal Group Technique represents group consensus has received much debate. Both Chapple (1996) and Lomax (1984) suggest that results obtained from the process may contradict the concept of group consensus previously defined. However, the process does produce a group decision that can be utilized for MODA input. This decision is generally better than input from one individual because it reflects the views of many experts.

Delphi Technique.

The Delphi Technique is the third group decision method that can be utilized for MODA. Like the first two discussed, it is flexible enough for use in all aspects of MODA. Delphi is an alternative to face to face group decisions designed to counteract

the negative effects of dominant personalities, conversation not pursuant to the problem, and open group pressure for conformity through anonymity (Dewar, 1996). “The tenet underlying the Delphi technique is that the consensus will improve with successive rounds of anonymous group judgments” (Hornsby, 1994).

Anonymity is one of the main advantages of the Delphi Technique. Anonymity serves the purpose of eliminating undue social pressures from individuals or environment (Rowe, 1999). Additionally, it gives the facilitator the ability to utilize experts without having to gather them in one place. This saves money and time while possibly providing an incentive for an expert to participate. According to Macphail (2001), Delphi is appropriate for groups that are unable to meet face to face.

Large group size is not an issue that would limit the use of the Delphi technique. “It can be used when the number of participants exceeds the number with which it is impossible to conduct meaningful face-to-face discussion” (Mitchell, 1991:339). Alternatively, small groups should be avoided when using the Delphi method. Mitchell (1991) points out that the optimal size for the group is no less than eight to ten members.

Facilitation is not as important an issue with the Delphi method when compared to the other two identified. Despite there is no face to face interaction, there is communication of ideas and clarification between group members. The interaction is kept anonymous and puts workload on the process facilitator to ensure accurate communication of the ideas expressed. Facilitation is required for Delphi, but it is a different form and does not require the people skills necessary for the other two methods.

The overall amount of time it takes to reach a group decision using the Delphi method can be large. “A great deal of preparation is required due to the nature of written

communication" (Srisoepardani, 1996). Once the process begins, the facilitation of this method can require a lot of time to complete. This is based on the statistics and feedback that needs to be consolidated and provided between rounds. Additionally, the number of rounds it takes to reach a consensus answer may be lengthy. Although four rounds is the optimal amount in utilizing Delphi (Erffmeyer, 1986), the number can be reduced in the effort of reaching a decision faster.

One negative aspect of the Delphi technique is the lack of support for the group decision from members that provided answers different from the consensus (Guzzo, 1982). A separate negative aspect pointed out by Guzzo (1982), is that the non-verbal interaction allowed under the method may not necessarily allow complete understanding of issues involved. The Delphi technique will not work if face to face interaction is needed for the benefits of "group spontaneity and creative interaction" (Souder, 1980).

The ability to maintain the group of experts through the entire process is critical to the Delphi technique. According to Mitchell (1991), high panel attrition is a common problem to Delphi applications. "Many respondents find the exercise more burdensome than anticipated. High rates of attrition may mean that the final results are based upon an unrepresentative sub sample of the original sample" (Mitchell, 1991:341).

Another criticism is that the Delphi method does not provide true consensus (Sackman, 1975), but rather a statistically aggregated consensus decision like the nominal group technique. This may lead to dissatisfaction for the group members that answered significantly different than the consensus decision. The group member may not accept or support the consensus decision reached.

Taxonomy Table

The review of the three group decision methods and their applicability to MODA is captured in a taxonomy table. The applicable methods are displayed in the columns and the criteria for use are displayed in the rows. An “X” displayed at the intersection of a method and criteria indicate applicability. Table 3 displays the group decision methods applicable to different aspects of MODA.

Table 3. MODA-Group Decision Taxonomy

MODA - Criteria/Driving Questions	Face to Face Group Interaction	Nominal Group Technique	Delphi Technique
MODA			
Structuring	X	X	X
Weighting	X	X	X
Scoring	X	X	X
Group Size			
Small Group (2-10)	X	X	
Medium Group (11-30)	X	X	X
Large Group (31+)		X	X
Geographic Location			
Collocated	X	X	X
Separated			X
Facilitation			
Requires Experienced Facilitator/Leadership		X	
Requires Facilitator			X
Enhanced Through Facilitation	X		
Group Dynamics			
Open Discussion of Ideas	X		
Clarification of Ideas - Structured Discussion		X	
Clarification of Ideas - No Discussion			X
Counters Dominant Personalities		X	X
Counters Irrelevant Conversation		X	X
Counters Pressure to Conform		X	X
Force All Experts to Participate		X	X
Possibility of Attrition of Group Members			X
Expert Perception			
Expert Feels Involved	X		
Expert Tends to Accept Decision	X		
Expert Feels Satisfied With Process	X	X	
Time Required to Complete			
Extensive Amount of Time			X
Moderate Amount of Time		X	X
Minimal Amount of Time	X	X	
Preparation Required			
Extensive			X
Moderate		X	X
Minimal	X		
Resources Required			
Meeting Place	X	X	
Office Supplies		X	
Output From the Method			
Requires Complete Agreement	X		
Determined Through Statistical Aggregation		X	X
Possibility of No Group Decision	X		
Possibility Decision is Not True Consensus		X	X

Chapter Summary

The methodology utilized for this thesis effort has been provided in this chapter. The second objective of this research effort has been accomplished through the identification of group decision making methods applicable to MODA. Face to face interaction, the Nominal Group Technique, and the Delphi Technique were reviewed for pros and cons, applicability, and appropriate use. The result of this review is a taxonomy reference table to link the decision methods to driving questions or criteria that are of concern when conducting MODA. This taxonomy will be utilized to analyze the group decision process utilized for the CAFPPAT.

IV. CAFPPAT Group Decision Analysis

Chapter Overview

This chapter provides the documentation and analysis of the group decision making process utilized for CAFPPAT input. This analysis provides feedback and constructive insight into the process used by the ACC/DRYR analysis team. Additionally, the current process is compared to the taxonomy table created in Chapter III. This analysis identifies the characteristics of the CAFPPAT process that support the use of the group decision methods identified in the taxonomy.

CAFPPAT Group Decision Task

The CAFPPAT group decision process is utilized for the structuring and weighting of the model as well as the scoring of solutions. The particular group decision process observed for this research effort focused on the task of structuring and weighting campaign level task dimensions. This is done to improve the ability to evaluate current task performance while eliminating model independence problems and time constraints (Hickman, 2002d).

Two meetings were conducted to address the neutralization and ISR campaign level tasks dimensions respectively. The group decision process that was observed for these two meetings is not unique to the structuring and weighting of task dimensions. The same process and methods are used for all phases of the CAFPPAT (Hickman, 2002d). Therefore, the insight gained into the group decision making process is applicable to the entire model.

CAFPPAT Group Decision Process

The CAFPPAT group decision process captures aspects of different group decision methods, not strictly following any one in particular. Four key aspects of group decision making are critical to analyzing this process. The setting, group composition, process mechanics, and facilitation are fundamental to analyzing this group decision method.

The setting of the two group decision meetings was the office of ACC/DRYR. The office has a central conference area which is used for face to face group interaction. A computer, projector, and whiteboard were utilized for presentation and facilitation purposes. Additionally, poster sized model hierarchies, charts, and task lists were available for the meetings. The setting allowed full participation of all group members, but the work space available to each individual was minimal.

The groups of SME were made up of both active duty military and civilian employees. The group that worked on the neutralization task dimensions consisted of nine individuals with eight of them being active duty or retired military. These nine individuals represented a mix of operators from a variety of aircraft and analysts with extensive experience. A few of the SME utilized for this portion of the CAFPPAT are responsible for the creation of modernization plans. The group that worked on the ISR task dimensions consisted of five individuals. Three of the five are intelligence professionals and are experienced in their field. These groups contained military ranking from captains to lieutenant colonels, high ranking civilians, and defense contractors.

The process that was utilized for group decision making is based upon face to face group interaction. This method is used to discuss and debate the issues under

consideration. Individual knowledge is shared and different perspectives were presented for group consideration. However, the consensus group decisions were obtained in different ways throughout the two meetings. The difference was based on the task presented to the group.

The structuring of task dimensions was completed using face to face interaction to revise a straw man, resulting in a group consensus answer. The weighting of the task dimensions was accomplished by soliciting weights from each individual. These weights were then averaged to obtain the group weights for the neutralization task dimensions. The averaging served the purpose of discord resolution between SME. In addition, the averaging saved time by not requiring group agreement on the appropriate weight. The averages were then presented to each individual at a later time for review and feedback. Similar to the Delphi Technique, numerous iterations of this review and feedback process were conducted to reach a consensus weighting scheme.

The ISR task dimension weights were obtained through discussion and compromise. A possible reason for this is the small size of the group. A summary of the group decision methods used for the two meetings just discussed is presented in Table 4. Note that face to face group interaction is the primary method utilized with some statistical aggregation.

Table 4. Observed Group Decision Process Summary

Neutralization Task Dimensions	Face to Face Group Interaction	Statistical Aggregation - Averaging
Structuring	X	
Weighting		X
ISR Task Dimensions		
Structuring	X	
Weighting	X	

Extensive facilitation was provided by the lead CAFPPAT analyst throughout both meetings. Due to the complexity of the CAFPPAT, time was spent providing an overview of the model and the specifics of the tasks that the group needed to confront. The lead analyst facilitated the group decisions by sparking discussion and providing interjection when necessary. A whiteboard, computer, and projection system were used by the facilitator throughout the meetings. This allowed the recording of preferences and information to be viewed by the entire group. Facilitation was necessary to maintain group focus and stop irrelevant conversations.

Analysis and Insight

The group decision process utilized for CAFPPAT is informal, flexible, and constrained by time and resources. The process mixes aspects of face to face interaction and the Delphi method. Different aggregation techniques are used to obtain group consensus answers based on the task performed. Many aspects of this group decision process are sound and contribute to obtaining quality group decisions. However, there are also aspects of the process that could be improved, resulting in better inputs into the CAFPPAT.

Group Decision Making Issues

There are many issues facing the ACC/DRYR analysis team that make utilization of SME for CAFPPAT input difficult. Some of the issues can be addressed by applying the group decision making methods identified in Chapter III. The remainder of the issues will need to be addressed through alternative means.

The first issue is the availability and utilization of experts for model participation. The most suitable expert is desired for each particular part of the CAFPPAT construction. Based on limitations such as time constraints and mission requirements, the most appropriate SME is not always available to participate in the CAFPPAT construction. The same issues cause SME that have participated in the CAFPPAT process at one time to be unavailable for repeated use. This is an issue because a replacement expert will have no comprehension of the CAFPPAT and will need to be educated on the model.

These issues of availability and use of SME could be countered by eliminating the need to meet in face to face groups. The use of the Delphi method will allow SME to participate in the CAFPPAT process without having to gather in one location. It will also allow the SME to work on the CAFPPAT input without investing the considerable amount of time involved in sitting through a group session. This will allow the participation of the most appropriate expert, as opposed to a less experienced, available individual.

Group composition and group dynamics play a role in the answers obtained from the current CAFPPAT group decision making process. The observed group decision process allows the voluntary exclusion of some members of the group when making decisions. This particular process does not require inputs from all of the group members. This allows some of the group decisions to be made by a minority of the experts participating. This lack of input from some group members could be the result of lack of expertise or group social pressures.

The facilitator made sure to query for compliance on all group decisions made during the observed process. Every group member was given the opportunity to interject

and disagree with the decisions reached. However, the lack of interjection does not support the conclusion that a consensus answer was obtained each time.

The mixture of varying rank, experience levels, and personalities present during the process also suggest the existence of group dynamics capable of impacting the quality of decision made. Individuals with strong personalities participated and often led the discussion and debates. However, during the observed process, there was no blatant evidence of pressure for conformity or the exertion of influence. The participants of the observed process were professional in dealing with each other. This may not always be the case in soliciting group decisions.

The use of the Nominal Group Technique or the Delphi Technique will help to prevent the negative effects that can result from dominant personalities and pressures for conformity. These two group decision methods will also solicit input from every member of the group, ensuring full participation. Both of these techniques provide an environment more conducive to a less confident group member to participate.

One issue that cannot be corrected through group decision methods is SME comprehension and support of CAFPPAT. Due to its high level of complexity and depth, extensive effort is required to educate SME on the model. Lack of understanding translates into skepticism of the process and the results obtained. Only through communication and model simplifications, if possible, will this issue be addressed.

Three other issues surfaced in observing the current CAFPPAT group decision process that will not be corrected through the use of group decision methods. The complexity of the model often makes it difficult to sustain the focus of the SME. Additionally, there sometimes exists a variation of definitions between SME when

interpreting model specifics. Finally, the tasks of structuring and weighting were accomplished concurrently due to the need to revise the structure. The combination of these three issues can lead to conflicts and the stagnation of the group decision process.

Strong facilitation may improve the focus of SME on the task at hand. The initial facilitation intended to provide the necessary level of comprehension is critical to solving this problem. Improvement in the ability to provide model comprehension will lead to buy in and improve the focus of the SME. The conflicts over definition variation were resolved through facilitation. This is the most appropriate way of dealing with this issue based on the fact that experts will always have different knowledge and perspectives that will need to be reconciled. Separate meetings should be conducted to structure and weight the model. The division of these tasks will facilitate efficiency in accomplishing each portion of the CAFPPAT. A visual summary of the issues hindering CAFPPAT group decision making is provided in Figure 18.

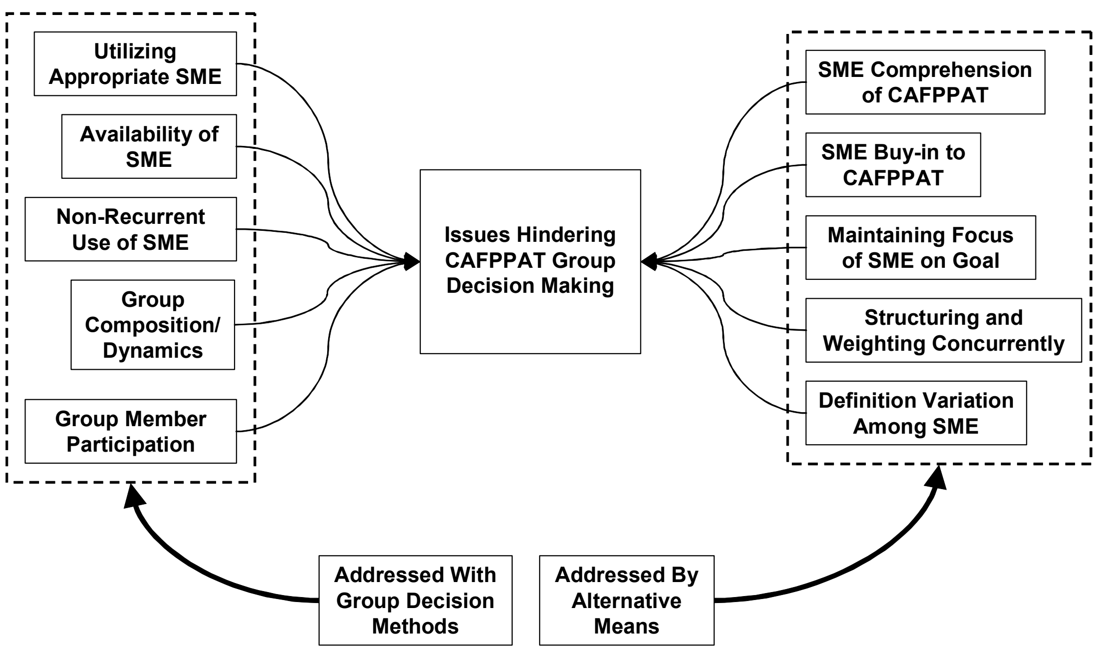

Figure 18. CAFPPAT Group Decision Issues

Taxonomy Comparative Analysis

The group decision making taxonomy that was presented in Chapter III provides a basis for analyzing the CAFPPAT group decision making environment. This analysis will identify the method applicable for each particular aspect of CAFPPAT group decision making. The methods identified could change based on the dynamic nature of the model and the resources available for ACC/DRYR use.

Face to face group interaction, the Nominal Group Technique, and the Delphi Technique are all applicable for use in the CAFPPAT. All three of these methods are capable of structuring, weighting, and scoring. No delineation between methods is evident based on the portion of the model under consideration.

Face to face group interaction and the Nominal Group Technique are best suited for the CAFPPAT when considering the issue of group size. There is a high probability that there will be a minimal number of experts available to work on the model at one time. The two methods identified are best suited for small to medium sized groups. If the possibility exists to utilize a group size larger than 30 experts, the Delphi Technique would be the most applicable method.

The issue of geographic location is fundamental in choosing a group decision method for the CAFPPAT. If all of the experts are located in the same location, any of the three methods can be utilized. However, if the best experts to use for the CAFPPAT are geographically separated, the Delphi Technique would be the only applicable method.

Facilitation is a critical part of the current CAFPPAT group decision process due to the complexity of the model and tasks to be accomplished by the groups. Given that facilitation is critical and already exists in the process, the Nominal Group and Delphi

Techniques could be utilized. The use of these two methods would require the current facilitation to be redirected to properly implement these two methods.

The issue of group dynamics and the detrimental effects that they can cause can be addressed through the use of the Nominal Group and Delphi techniques. The use of these two methods eliminates the open discussion of ideas, but not clarification of the ideas presented. It should be noted that the use of the Delphi Technique for the CAFPPAT can result in the attrition of group members due to the time it takes to complete the process.

The concept of expert perception and time available to complete the CAFPPAT are two issues addressed by the taxonomy. Face to face group interaction is the most applicable method for the CAFPPAT if the individual sense of involvement, satisfaction, and decision acceptance of each expert is critical. It should be noted that the Delphi Technique, based on the taxonomy, does not satisfy any on these perception criteria. If the time available to complete applicable portions of the CAFPPAT is minimal, face to face group interaction and the Nominal Group Technique should be used. The Delphi Technique should be utilized when an extensive amount of time is available.

In congruence with the time requirement, the amount of preparation required to utilize the Delphi Technique is extensive. The face to face group interaction method requires the least preparation to utilize. This method is appropriate when time constraints and resources such as facilitators and support personnel are not available. The current resources available to ACC/DRYR suggest the use of this method based on the preparation criteria.

The final comparison between the taxonomy and the CAFPPAT group decision making process focuses on the output required. If the output from the group decision making method requires complete agreement, face to face group interaction is the appropriate method. However, the use of this method allows the possibility of not obtaining a group decision based on discord. If the CAFPPAT can use output that is determined through statistical aggregation, the Nominal Group and Delphi Techniques should be utilized. It should be noted that the results obtained from statistical aggregation should not be considered true group consensus.

Chapter Summary

This chapter has provided analysis and insight into the current group decision making process utilized for the CAFPPAT. The current process was identified based on the observation of two campaign level group decision making meetings. This process is evaluated in the context of setting, group composition, process mechanics, and facilitation. The issues hindering group decision making are presented based on the observations obtained from the two meetings. The ability of the taxonomy group decision methods to solve the issues identified is presented. Finally, a comparison is made between the criteria provided in the group decision making taxonomy and the CAFPPAT group decision process. The most applicable methods are identified for each particular criteria of the CAFPPAT.

V. Summary Discussion

Introduction

The intent of this chapter is to provide an overview of this research effort. The motivation for this research will be presented and the objectives will be restated. A summary of the results will be presented with the limitations of this effort being identified. In conclusion, areas for further research will be suggested for the CAFPPAT and group decision making.

Background

Modernization planning is one critical component of the current Air Force transformation effort. The requirement to transform into a more agile, expeditionary force, dictates that the Air Force strive for maximum return on investment. The allocation of scarce taxpayer dollars to sustain the current force and build new systems is critical to the future success of the Air Force. The focus of modernization planning is the capabilities that are required for the Air Force to fight and win in future conflicts.

Capabilities based modernization planning is accomplished through qualitative and quantitative methods. The use of quantitative decision analysis methods focuses on structuring complex decision problems and providing outputs useful to decision makers in allocating scarce resources. One decision analysis method that is seeing an increase in use is multi-objective decision analysis (MODA). Air Combat Command (ACC) has created a MODA model to support their capabilities based modernization planning.

The Combat Air Forces Planning and Programming Analytical Tool analyzes the capabilities of the Combat Air Forces (CAF). This model provides an assessment of the

current CAF capabilities and identifies the areas where shortfalls exist. This model provides a method to evaluate potential solutions in regards to improving or eliminating capability shortfalls. Subject matter experts (SME) are fundamental to the successful use of this type of decision analysis model. Experts are used in lieu of the actual senior level decision makers due to time constraints. The use of SME provides a broad range of experience which is then combined to provide model inputs.

The efficient utilization of experts directly relates to the quality and fidelity of the output generated from MODA models. Numerous group decision methods exist that allow a group of people to produce an output. However, differences in mathematical rigor, complexity, and the specific criteria of the MODA tools make the use of some group decision methods infeasible. The identification of group decision methods that are applicable and feasible to MODA tools allows efficient use of groups of experts. It is the hope of this research effort that efficient use of experts will cause a waterfall effect improving the output of MODA models and modernization planning.

Research Objectives

This research effort focused on satisfying three different goals. One goal was the generalization and documentation of the quantitative decision making tool utilized by ACC for modernization planning. The second goal was to identify group decision making methods that are applicable to multi-objective decision making models. Finally, the third goal was to analyze and provide insight into the group decision making process utilized by ACC for their decision tool. These three goals are stated as the following research objectives:

1. Analyze, generalize and document the CAFPPAT.
2. Based on literature, develop a comprehensive taxonomy for group decision making.
3. Observe, document, and analyze the group decision making process utilized for the CAFPPAT campaign level and provide insight.

Research Summary

The generalization and documentation of the CAFPPAT was accomplished through literature review and iterations of model familiarization briefs by the ACC/DRYR staff. The result is an overview of the model that encompasses the motivation, key components, outputs, and flexibility of use. The documentation provides a general understanding of what the model is and how it produces output in support of modernization planning. This satisfies the first research objective of providing a documented reference of the CAFPPAT.

An extensive literature review of decision theory identified three group decision making methods applicable to MODA. The three methods identified are appropriate for use based on different criteria discovered in the literature review. The methods and criteria were combined into a taxonomy reference table satisfying the second research objective. This table allows the users of MODA to identify the criteria specific to their MODA situation and choose the most applicable group decision method.

The taxonomy table was then utilized to provide insight into the current group decision process utilized for the CAFPPAT. The current process was observed and documented for one portion of the CAFPPAT. Constructive insight was provided to

identify the issues that hinder the effective use of groups. Aspects that could be improved through application of the MODA applicable group decision methods were identified. Issues that could not be solved by the group decision methods were also identified and discussed. This part of the research effort satisfied the third and final research objective.

Recommendations

The utilization of group decision making methods is dependent upon the context of the MODA being conducted. The analysis of the CAFPPAT demonstrated that no one method is best suited for all aspects of MODA. There are certain aspects of a MODA context that force the use of a particular method. One example is the geographic separation of SME which dictates the use of the Delphi Technique.

The analysts conducting MODA need to carefully evaluate the criteria applicable to their decision situation and utilize the method best suited. A combination of methods may be utilized for different stages of the MODA process. Analysts need to determine which criteria are most applicable to their decision context and which are most critical in generating sound group outputs. This will allow the best possible input into their MODA models improving credibility and output.

Limitations of this Research

A limitation of this research effort is the small amount of group decision making that was actually observed. The documentation and analysis of the current CAFPPAT group decision making process is based on two meetings. The process observed at these two meetings was identified as universal to the CAFPPAT. However, additional insight

and analysis could be conducted with the observation of more group meetings. This would allow the generation of more complete representation of the current CAFPPAT group decision process.

A second limitation is the documentation of the CAFPPAT model. This overview of the CAFPPAT omits many of the process mechanics critical to generating outputs from the model. The complexity of the model and the focus on the role of group decision making did not allow a more detailed discussion of model mechanics. A review encompassing a higher level of detail will provide a useful reference for analysts constructing a model of similar complexity.

The final limitation of this research deals with the issue of group decision support systems (GDSS). GDSS are defined as "computer-based systems and methods developed to facilitate group decision making" (Zahedi, 1996:270). Improving communication, increasing participation, and providing a variety of support functions to group processes are three examples of the many uses of GDSS (Zahedi, 1996). The use of these systems is increasing and the effect that they may have on the group decision making taxonomy was not researched.

Follow-on Research

This research effort provides many possibilities for further research in regards to both the CAFPPAT and group decision making. The CAFPPAT is continuously evolving and improving to better accomplish its intended purpose. The ACC/DRYR staff is pursuing numerous efforts in an attempt to improve the model. Three specific topics would improve the fidelity, credibility, and usefulness of the model.

One area of research is the validation and verification of the decision analysis methods used for the CAFPPAT. This research should focus on the hierarchies, weighting schemes, and the combination of model components to produce top level outputs. The goal of this research would be to identify areas of deficiency and validate the areas that do follow approved decision analysis methods. This would allow ACC/DRYR to improve these areas and increase the credibility of the CAFPPAT.

A second topic useful to the CAFPPAT is the development of an Air Force capabilities construct. This would require reviewing and updating the current task lists that represent Air Force capabilities. The goal of this effort would be to ensure all the necessary capabilities were included. The capabilities construct would improve the use of the CAFPPAT and could be utilized Air Force wide for modernization planning.

Finally, the creation of visual tools to display the output generated from the CAFPPAT would increase the usefulness of the model to senior level decision makers. The current model output is not generated in a format easily understandable to decision makers inexperienced with decision analysis tools. This effort would allow ACC/DRYR to provide comprehensive decision analysis support to ACC leadership that is simple to use and easy to understand.

There are numerous topics worthy of further research in regards to group decision making and applicability to MODA models. The verification and validation of the group decision making taxonomy created in this research effort is one area for future research. This taxonomy could be evaluated through application on previously completed MODA models. The results obtained through the use of the appropriate group decision method could be compared to the results originally obtained. A comparative analysis of the

results obtained may provide insight into the relative worth of taxonomy and methods identified.

Voting was identified in Chapter III as a legitimate group decision method. However, it was not included in the taxonomy due to the variety of forms of voting and the fact that the methods identified often use some type of voting. A topic of further research is to identify which form of voting would be most applicable for MODA applicable group decision methods. This would allow analysts utilizing group decision methods to use the form of voting that will generate the best group answer for MODA input.

The group decision making taxonomy created in this research could be expanded to address the use of creativity techniques that are applicable to the structuring phase of MODA models. The structuring of MODA models is critical in ensuring that a decision analysis tool is comprehensive in addressing the decision problem. The inclusion of creativity techniques and criteria for their appropriate use would strengthen the process of conducting MODA.

The constant increase in technology and the emergence of group decision support systems (GDSS) provide a new avenue to improve group decision making. The impact that GDSS have on the quality of group decisions is worthy of research. Additionally, the identification of GDSS applicable to MODA could be used to expand the taxonomy of group decision making methods.

Conclusion

The use of multi-objective decision analysis is well suited to the complex decision problems faced both in the public and private sectors. The ability to provide structure, objectivity, and repeatability when evaluating potential solutions to complex problems motivates the use of MODA. Subject matter experts are fundamental to the use of this form of decision analysis. The more experts that can be utilized improve the breadth of input generated.

The problem of combining the input generated from groups of experts is one crucial to decision analysis. Sound group decision making methods are needed to ensure the decision generated is credible and useful. The relationship of these group decision making methods and MODA is critical in producing quality outputs useful to decision makers. This relationship will only increase in importance as the complexity of decisions faced by leaders continues to increase.

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Appendix A. List of Acronyms and Abbreviations

AAR	Air to Air Refueling
ACC	Air Combat Command
ACC/DR	Directorate of Requirements
ACC/DRPX	Policy Analysis
ACC/DRY	Analysis Division
ACC/DRYR	Resource Analysis Branch
AFI	Air Force Instruction
AFPD	Air Force Policy Directive
AFPP	Air Force Program Projection
AFRAP	Air Force Resource Allocation Process
AFRC	Air Force Reserve Command
AFSAA	Air Force Studies and Analysis Agency
AFSP	Air Force Strategic Plan
AFSPC	Air Force Space Command
AHP	Analytical Hierarchy Process
AMC	Air Mobility Command
ANG	Air National Guard
ASIIS	Aerospace Integrated Investment Study
C2	Command and Control
C4	Command, Control, Communications, and Computers
CAF	Combat Air Forces
CAFPPAT	Combat Air Forces Planning and Programming Analytical Tool
CONOPS	Concept of Operations
CSAR	Combat Search and Rescue
DoD	Department of Defense
DPG	Defense Planning Guidance
EAF	Expeditionary Aerospace Force
FY	Fiscal Year
GDSS	Group Decision Support System
IPP	Integrated Planning Process
ISR	Intelligence, Surveillance, and Reconnaissance
JSF	Joint Strike Fighter
MAJCOM	Air Force Major Command
MAA	Mission Area Assessment
MAP	Mission Area Plan
MAT	Mission Area Team
MAUT	Multiple Attribute Utility Theory
MCDM	Multiple Criteria Decision Making
MIDB	Modernized Integrated Database
MNA	Mission Needs Analysis
MODA	Multi-Objective Decision Analysis

MPP	Modernization Planning Process
MSA	Mission Solution Analysis
MSP	Mission Support Plan
PACAF	Pacific Air Forces
PEM	Program Element Monitor
POM	Program Objective Memorandum
PPBS	Planning, Programming, and Budgeting System
RAM	Resource Allocation Model
SME	Subject Matter Experts
USAFE	United States Air Forces in Europe
VFT	Value Focused Thinking

Appendix B. Classification of the Techniques and Methods Reviewed

Facilitation/Creativity Techniques	Group Decision Methods	Decision Analysis Techniques
A Questioning Attitude	Aggregation Using Conjugate Distributions	Analytical Hierarchy Process
Affinity Diagrams	Cooperative Game Theory	Bayesian Analysis
Analogies/Metaphors	Delphi Technique	Conjoint Measurement
Attribute Association	Expert Use Model	Copeland Method
Boundary Examination	Face to Face Interaction	Cost-Benefit Analysis
Brain Writing	Group Utility Analysis	Decision Trees
Brainstorming	Krzysztofowicz Group Consensus Method	Fuzzy Logic
Bug List	Nominal Group Technique	Goal Programming
Constructive Response	Probabilistic Approach	Group Goal Programming Method
Crawford Blue Slip	Voting	Group Naïve Search
Decomposable Matrices	Weighted Linear Combinations	Group Step Method
Devil's Advocate Approach	Zahedi Group Consensus Method	Hurwicz Criterion
Dialectical Approach		Influence Diagrams
Disjointed Incrementalism		Process
Fish Bowl		Matrix Evaluation
Fluent and Flexible Thinking		Maximin Method
Force Field Analysis		Multiple Criteria Decision Making
Go-Around		Opportunity Loss Tables
Guided Discussion		Payoff Matrices
Idea Checklists		Politometric Multivariate Modeling
Interrogatories (5Ws/H)		Principle of Insufficient Reason
Left/Right Brain Alterations		Probabilistic Dynamic Programming
Lotus Blossom		Probability Models
Manipulative Verbs		Quality Function Deployment
Morphological Forced Connections		Regret Tables
Multi-Voting		Risk Ranking Technique
Peaceful Setting		Risk Reduction Method
Please State Your Needs		Schwartz Method
Problem Reversal		Utility Tables
Progressive Abstraction		Utility Theory
Put It In the Hangar		Value Focused Thinking
Q-Methodology		
Take Five		
The Gordon Method		
Why-What's Stopping		
Wildest Idea		
Wishful Thinking		

VITA

Captain Ian L. Walker graduated from Mexico Academy High School in Mexico, New York. He entered undergraduate studies at the State University of New York at Geneseo where he graduated with a Bachelor of Science degree in Accounting in May 1997. Upon graduation, he attended the Air Force Officer Training School and was commissioned in September 1997.

His first assignment was the Chief of Financial Services for the 347th Comptroller Flight at Moody AFB, Valdosta, Georgia. While stationed at Moody, he completed a Master of Science degree in Public Administration through Valdosta State University and was recognized as a Distinguished Graduate. In December 1999, he was reassigned to the 65th Comptroller Flight, Lajes Field, Azores, Portugal. While stationed at Lajes, he briefly served as Chief of Financial Services and then spent the remainder of the tour as Chief of Financial Analysis.

In August of 2001, he entered the Graduate School of Engineering and Management, Air Force Institute of Technology to obtain a Master of Science degree in Cost Analysis. Upon graduation, Capt Walker will be assigned to Electronic Systems Center, Hanscom AFB, Massachusetts as a weapons system cost analyst.

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14. ABSTRACT

Modernization is a critical component of the current transformation effort within the Department of Defense (DoD). Effective and efficient modernization planning will provide for the improved allocation of limited funding. The Air Force currently conducts capabilities based modernization planning to identify shortfalls. Air Combat Command (ACC) utilizes multi-objective decision analysis (MODA) techniques to support the modernization planning process (MPP). A MODA model has been created to identify and quantify capability shortfalls across a diverse range of mission areas. Groups of subject matter experts are utilized to provide model inputs improving the usefulness and credibility of the model.

The intent of this research effort is to document the ACC modernization model and provide insight into their use of groups. A methodology is created to identify appropriate group decision making techniques for use in MODA. The resulting taxonomy table is then used to analyze the group decision process used for the ACC model. The documentation of the model provides a reference of MODA use in modernization planning. The methodology created will provide a reference for the use of group decision making techniques in MODA. The identification of areas where group decision making techniques can be applied to the ACC model provides insight capable of strengthening the model and its output. This will provide improved quantitative information to modernization decision makers.